S T S LAB

RADIO TEST REPORT

Report No: STS1907281W02

Issued for

Xmi Pte Ltd

994, Bendemeer Road, B-Central, #04-04, Singapore 339943.

Product Name:	LIBERTY+ True Wireless In-Ear Headphones
Brand Name:	X-mini
Model Name:	XAM42
Series Model:	N/A
FCC ID:	A4VXAM42
Test Standard:	FCC Part 15.247

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TEST RESULT CERTIFICATION

Applicant's Name .....:	Xmi Pte Ltd
Address .....:	994, Bendemeer Road, B-Central, #04-04, Singapore 339943.
Manufacture's Name .....:	Xmi Pte Ltd
Address .....:	F4,5,BlockB,F3,Building A, Shanghe Industrial Park, Nanchang Village, Hangcheng Avenue, Xixiang Town,Bao'an District,Shenzhen City, Guangdong Province, China. (Zip Code:518103)

Product Description

Product Name .....:	LIBERTY+ True Wireless In-Ear Headphones
Brand Name .....:	X-mini
Model Name .....:	XAM42
Series Model .....:	N/A
Test Standards .....:	FCC Part15.247
Test Procedure .....:	ANSI C63.10-2013

This device described above has been tested by STS, the test results show that the equipment under test (EUT) is in compliance with the FCC requirements. And it is applicable only to the tested sample identified in the report.
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Date of Test.....:

Date (s) of performance of tests.:	31 July 2019 ~ 30 Aug. 2019
Date of Issue .....:	30 Aug. 2019
Test Result .....:	Pass

Testing Engineer : Chris Chen

(Chris Chen)

Technical Manager : Sunday Hu

(Sunday Hu)

Authorized Signatory : Vita Li

(Vita Li)

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Revision History

Rev.	Issue Date	Report NO.	Effect Page	Contents
00	30 Aug. 2019	STS1907281W02	ALL	Initial Issue

1. SUMMARY OF TEST RESULTS

Test procedures according to the technical standards:
KDB 558074 D01 15.247 Meas Guidance v05r02

FCC Part 15.247,Subpart C			
Standard Section	Test Item	Judgment	Remark
15.207	Conducted Emission	PASS	--
15.247(a)(1)	Hopping Channel Separation	PASS	--
15.247(a)(1)&(b)(1)	Output Power	PASS	--
15.247©	Radiated Spurious Emission	PASS	--
15.247(d)	Conducted Spurious & Band Edge Emission	PASS	--
15.247(a)(iii)	Number of Hopping Frequency	PASS	--
15.247(a)(iii)	Dwell Time	PASS	--
15.247(a)(1)	Bandwidth	PASS	--
15.205	Restricted Band Edge Emission	PASS	--
Part 15.247(d)/part 15.209(a)	Band Edge Emission	PASS	--
15.203	Antenna Requirement	PASS	--

NOTE:

(1)" N/A" denotes test is not applicable in this Test Report

(2) All tests are according to ANSI C63.10-2013

1.1 TEST FACTORY

Shenzhen STS Test Services Co., Ltd.
Add. : 1/F., Building B, Zhuoke Science Park, No.190, Chongqing Road, Fuyong Street, Bao'an District, Shenzhen, Guangdong, China
FCC test Firm Registration Number: 625569
A2LA Certificate No.: 4338.01;

1.2 MEASUREMENT UNCERTAINTY

The reported uncertainty of measurement **y ±U**, where expended uncertainty **U** is based on a standard uncertainty multiplied by a coverage factor of **k=2**, providing a level of confidence of approximately **95** %.

No.	Item	Uncertainty
1	RF output power, conducted	±0.71dB
2	Unwanted Emissions, conducted	±0.63dB
3	All emissions, radiated 30-200MHz	±3.43dB
4	All emissions, radiated 200MHz-1GHz	±3.57dB
5	All emissions, radiated>1G	±4.13dB
6	Conducted Emission (9KHz-150KHz)	±3.18dB
7	Conducted Emission (150KHz-30MHz)	±2.70dB

2. GENERAL INFORMATION

2.1 GENERAL DESCRIPTION OF THE EUT

Product Name	LIBERTY+ True Wireless In-Ear Headphones
Trade Name	X-mini
Model Name	XAM42
Series Model	N/A
Model Difference	N/A
Channel List	Please refer to the Note 2.
Bluetooth	Frequency:2402 – 2480 MHz Modulation: GFSK(1Mbps), π/4-DQPSK(2Mbps), 8DPSK(3Mbps)
Bluetooth Version	5.0
Bluetooth Configuration	BR+EDR
Power Rating	Input: DC 5V,800mA
Battery	Rated Voltage: 3.7V Charge Limit: 4.2V Capacity: 50mAh
Hardware version number	V0.1
Software version number	V1.0
Connecting I/O Port(s)	Please refer to the User's Manual

Note:

1. For a more detailed features description, please refer to the manufacturer's specifications or the User's Manual.

2.

Channel List					
Channel	Frequency (MHz)	Channel	Frequency (MHz)	Channel	Frequency (MHz)
00	2402	27	2429	54	2456
01	2403	28	2430	55	2457
02	2404	29	2431	56	2458
03	2405	30	2432	57	2459
04	2406	31	2433	58	2460
05	2407	32	2434	59	2461
06	2408	33	2435	60	2462
07	2409	34	2436	61	2463
08	2410	35	2437	62	2464
09	2411	36	2438	63	2465
10	2412	37	2439	64	2466
11	2413	38	2440	65	2467
12	2414	39	2441	66	2468
13	2415	40	2442	67	2469
14	2416	41	2443	68	2470
15	2417	42	2444	69	2471
16	2418	43	2445	70	2472
17	2419	44	2446	71	2473
18	2420	45	2447	72	2474
19	2421	46	2448	73	2475
20	2422	47	2449	74	2476
21	2423	48	2450	75	2477
22	2424	49	2451	76	2478
23	2425	50	2452	77	2479
24	2426	51	2453	78	2480
25	2427	52	2454		
26	2428	53	2455		

3. Table for Filed Antenna

Ant.	Brand	Model Name	Antenna Type	Connector	Gain (dBi)	NOTE
1	X-mini	XAM42	ceramics	N/A	5.22 dBi	BT Antenna

2.2 DESCRIPTION OF THE TEST MODES

To investigate the maximum EMI emission characteristics generates from EUT, the test system was pre-scanning tested base on the consideration of following EUT operation mode or test configuration mode which possible have effect on EMI emission level. Each of these EUT operation mode(s) or test configuration mode(s) mentioned above was evaluated respectively.

Worst Mode	Description	Data Rate/Modulation
Mode 1	TX CH00	1Mbps/GFSK
Mode 2	TX CH39	1Mbps/GFSK
Mode 3	TX CH78	1Mbps/GFSK
Mode 4	TX CH00	2 Mbps/π/4-DQPSK
Mode 5	TX CH39	2 Mbps/π/4-DQPSK
Mode 6	TX CH78	2 Mbps/π/4-DQPSK
Mode7	TX CH00	3 Mbps/8DPSK
Mode 8	TX CH39	3 Mbps/8DPSK
Mode 9	TX CH78	3 Mbps/8DPSK

Note:

(1) The measurements are performed at all Bit Rate of Transmitter, the worst data was reported

(2) We have be tested for all avaiable U.S. voltage and frequencies(For 120V,50/60Hz and 240V, 50/60Hz) for which the device is capable of operation, and the worst case of 120V/ 60Hz is shown in the report

For AC Conducted Emission

Test Case	
AC Conducted Emission	Mode 10 : Keeping BT TX

2.3 TABLE OF PARAMETERS OF TEXT SOFTWARE SETTING

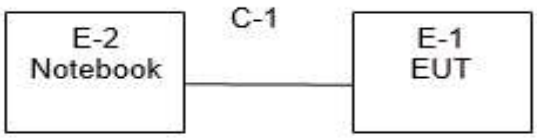
During testing channel & power controlling software provided by the customer was used to control the operating channel as well as the output power level. The RF output power selection is for the setting of RF output power expected by the customer and is going to be fixed on the firmware of the final end product power parameters of FHSS.

Test software Version	Test program: Bluetooth		
(Power control software) Parameters(1/2/3Mbps)	Power class: DH1 rate:4:27 2DH1 rate:20:54 3DH1 rate:24:83	Power class: DH3 rate:11:183 2DH3 rate:26:367 3DH3 rate:27:552	Power class: DH5 rate:15:339 2DH5 rate:30:679 3DH5 rate:31:1021

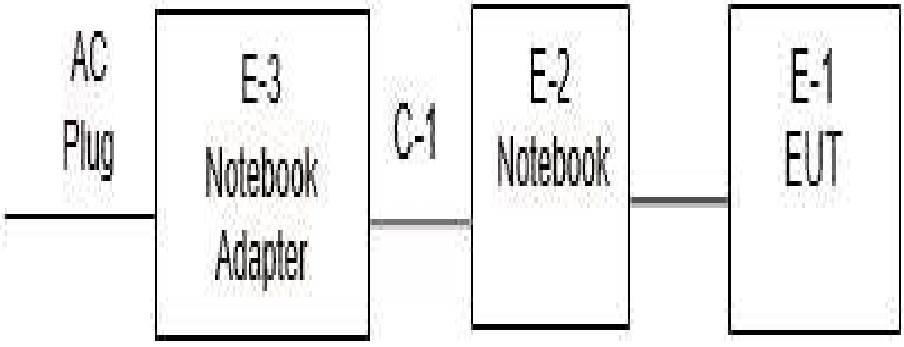
2.4 BLOCK DIGRAM SHOWING THE CONFIGURATION OF SYSTEM TESTED

During testing channel & power controlling software provided by the customer was used to control the operating channel as well as the output power level. The RF output power selection is for the setting of RF output power expected by the customer and is going to be fixed on the firmware of the final end product power parameters of FHSS

Radiated Spurious Emission Test



Conducted Emission Test



2.5 DESCRIPTION OF NECESSARY ACCESSORIES AND SUPPORT UNITS

The EUT has been tested as an independent unit together with other necessary accessories or support units. The following support units or accessories were used to form a representative test configuration during the tests.

Necessary accessories

Item	Equipment	Mfr/Brand	Model/Type No.	Serial No.	Note
N/A	N/A	N/A	N/A	N/A	N/A

Support units

Item	Equipment	Mfr/Brand	Model/Type No.	Serial No.	Note
E-2	Notebook	DELL	VOSTRO.3800	N/A	N/A
C-1	DC Cable	N/A	100cm	N/A	N/A

Note:

(1) The support equipment was authorized by Declaration of Confirmation.

(2) For detachable type I/O cable should be specified the length in cm in『Length』column.

(3) “YES” is means “shielded” “with core”; “NO” is means “unshielded” “without core”.

2.6 EQUIPMENTS LIST

Radiation Test equipment

Kind of Equipment	Manufacturer	Type No.	Serial No.	Last calibration	Calibrated until
Test Receiver	R&S	ESCI	101427	2018.10.13	2019.10.12
Signal Analyzer	Agilent	N9020A	MY51110105	2019.03.02	2020.03.01
Active loop Antenna	ZHINAN	ZN30900C	16035	2018.03.11	2021.03.10
Bilog Antenna	TESEQ	CBL6111D	34678	2017.11.02	2020.11.1
Horn Antenna	SCHWARZBECK	BBHA 9120D(1201)	9120D-1343	2018.10.19	2021.10.18
SHF-EHF Horn Antenna (18G-40GHz)	A-INFO	LB-180400-KF	J211020657	2018.03.11	2021.03.10
Pre-Amplifier(0.1M-3G Hz)	EM	EM330	060665	2018.10.13	2019.10.12
Pre-Amplifier (1G-18GHz)	SKET	LNPA-01018G-45	SK2018080901	2018.10.13	2019.10.12
Temperature & Humidity	HH660	Mieo	N/A	2018.10.11	2019.10.10
turn table	EM	SC100_1	60531	N/A	N/A
Antenna mast	EM	SC100	N/A	N/A	N/A
Test SW	FARAD	EZ-EMC(Ver.STSLAB-03A1 RE)			

Conduction Test equipment

Kind of Equipment	Manufacturer	Type No.	Serial No.	Last calibration	Calibrated until
Test Receiver	R&S	ESCI	101427	2018.10.13	2019.10.12
LISN	R&S	ENV216	101242	2018.10.11	2019.10.10
LISN	EMCO	3810/2NM	23625	2018.10.11	2019.10.10
Temperature & Humidity	HH660	Mieo	N/A	2018.10.11	2019.10.10
Test SW	FARAD	EZ-EMC(Ver.STSLAB-03A1 CE)			

RF Connected Test

Kind of Equipment	Manufacturer	Type No.	Serial No.	Last calibration	Calibrated until
USB RF power sensor	DARE	RPR3006W	15I00041SNO03	2018.10.13	2019.10.12
Signal Analyzer	Agilent	N9020A	MY49100060	2018.10.13	2019.10.12
Temperature & Humidity	HH660	Mieo	N/A	2018.10.11	2019.10.10
Test SW	FARAD	LZ-RF /LzRf-3A3			

3. EMC EMISSION TEST

3.1 CONDUCTED EMISSION MEASUREMENT

3.1.1 POWER LINE CONDUCTED EMISSION LIMITS

Operating frequency band. In case the emission fall within the restricted band specified on Part 207(a) limit in the table below has to be followed.

FREQUENCY (MHz)	Conducted Emissionlimit (dBuV)	
	Quasi-peak	Average
0.15 -0.5	66 - 56 *	56 - 46 *
0.50 -5.0	56.00	46.00
5.0 -30.0	60.00	50.00

Note:

(1) The tighter limit applies at the band edges.

(2) The limit of " * " marked band means the limitation decreases linearly with the logarithm of the frequency in the range.

The following table is the setting of the receiver

Receiver Parameters	Setting
Attenuation	10 dB
Start Frequency	0.15 MHz
Stop Frequency	30 MHz
IF Bandwidth	9 kHz

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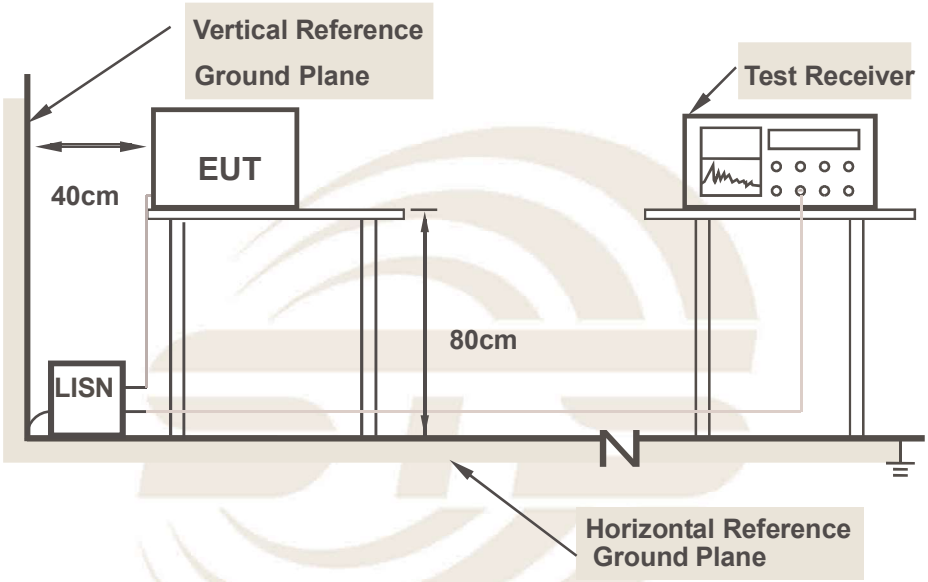
3.1.2 TEST PROCEDURE

a. The EUT was 0.8 meters from the horizontal ground plane and 0.4 meters from the vertical ground plane with EUT being connected to the power mains through a line impedance stabilization network (LISN). All other support equipments powered from additional LISN(s). The LISN provide 50 Ohm/ 50uH of coupling impedance for the measuring instrument.
b. Interconnecting cables that hang closer than 40 cm to the ground plane shall be folded back and forth in the center forming a bundle 30 to 40 cm long.
c. I/O cables that are not connected to a peripheral shall be bundled in the center. The end of the cable may be terminated, if required, using the correct terminating impedance. The overall length shall not exceed 1 m.
d. LISN at least 80 cm from nearest part of EUT chassis.
e. For the actual test configuration, please refer to the related Item –EUT Test Photos.

3.1.3 TEST SETUP



Note: 1.Support units were connected to second LISN.

2.Both of LISNs (AMN) are 80 cm from EUT and at least 80 from other units and other metal planes

3.1.4 EUT OPERATING CONDITIONS

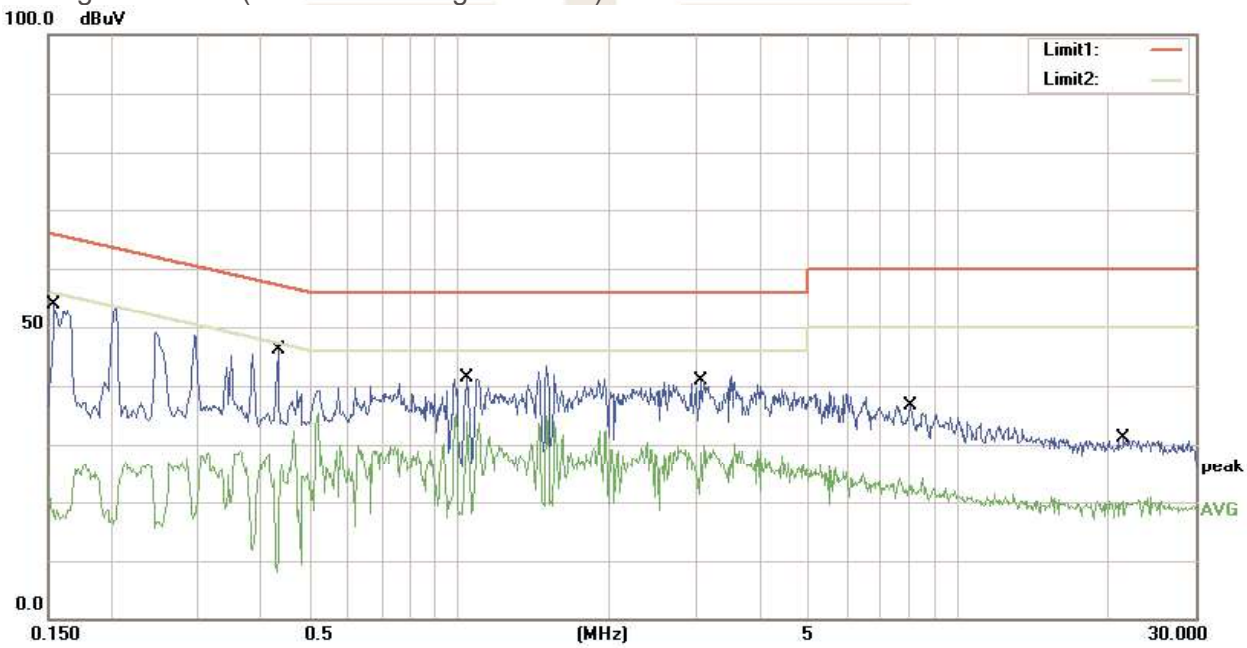
The EUT was configured for testing in a typical fashion (as a customer would normally use it). The EUT has been programmed to continuously transmit during test. This operating condition was tested and used to collect the included data.

3.1.5 TEST RESULT

Temperature:	26(C)	Relative Humidity:	60%RH
Test Voltage:	AC 120V/60Hz	Phase:	L
Test Mode:	Mode 10		

No.	Frequency (MHz)	Reading (dBuV)	Correct Factor(dB)	Result (dBuV)	Limit (dBuV)	Margin (dB)	Remark
1	0.1540	34.28	19.62	53.90	65.78	-11.88	QP
2	0.1540	4.40	19.62	24.02	55.78	-31.76	AVG
3	0.4340	26.38	19.67	46.05	57.18	-11.13	QP
4	0.4340	12.63	19.67	32.30	47.18	-14.88	AVG
5	1.0420	21.76	19.50	41.26	56.00	-14.74	QP
6	1.0420	15.52	19.50	35.02	46.00	-10.98	AVG
7	3.0460	21.54	19.45	40.99	56.00	-15.01	QP
8	3.0460	10.43	19.45	29.88	46.00	-16.12	AVG
9	8.0580	17.36	19.34	36.70	60.00	-23.30	QP
10	8.0580	4.86	19.34	24.20	50.00	-25.80	AVG
11	21.4860	10.97	20.18	31.15	60.00	-28.85	QP
12	21.4860	0.23	20.18	20.41	50.00	-29.59	AVG

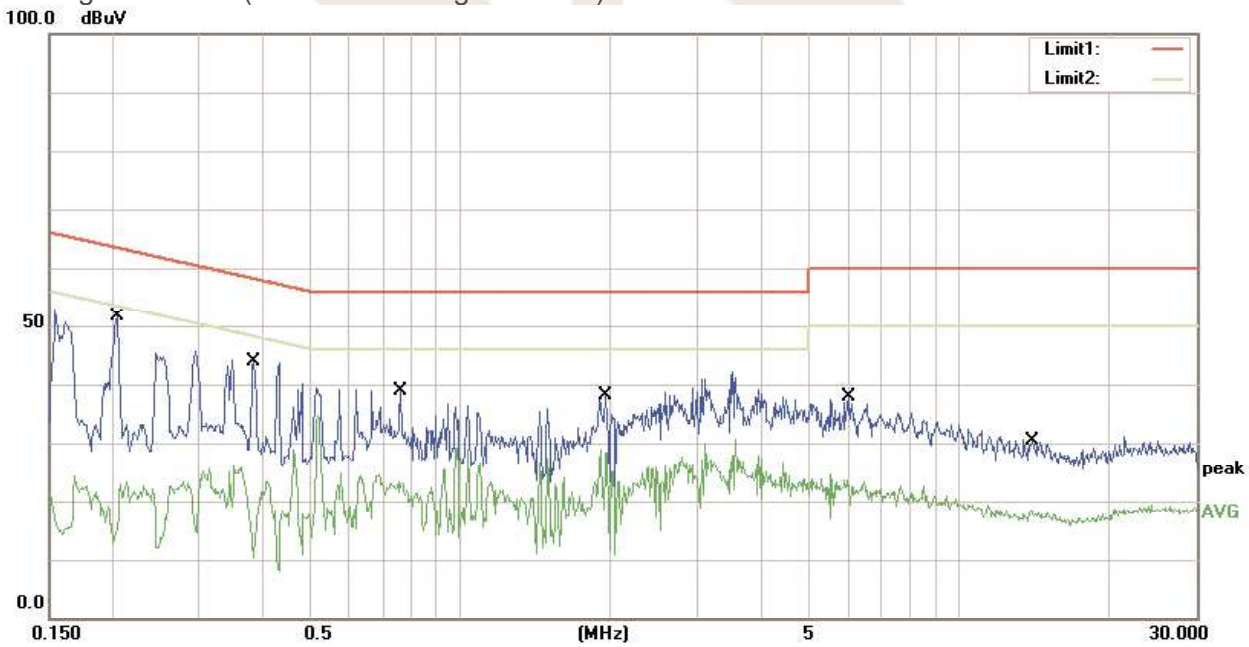
Remark:
1. All readings are Quasi-Peak and Average values.
2. Margin = Result (Result =Reading + Factor)–Limit



Temperature:	26(C)	Relative Humidity:	60%RH
Test Voltage:	AC 120V/60Hz	Phase:	N
Test Mode:	Mode 10		

No.	Frequency (MHz)	Reading (dBuV)	Correct Factor(dB)	Result (dBuV)	Limit (dBuV)	Margin (dB)	Remark
1	0.2060	31.90	19.62	51.52	63.37	-11.85	QP
2	0.2060	3.71	19.62	23.33	53.37	-30.04	AVG
3	0.3860	24.14	19.71	43.85	58.15	-14.30	QP
4	0.3860	3.65	19.71	23.36	48.15	-24.79	AVG
5	0.7620	19.37	19.62	38.99	56.00	-17.01	QP
6	0.7620	5.08	19.62	24.70	46.00	-21.30	AVG
7	1.9580	18.48	19.54	38.02	56.00	-17.98	QP
8	1.9580	9.24	19.54	28.78	46.00	-17.22	AVG
9	6.0380	18.53	19.30	37.83	60.00	-22.17	QP
10	6.0380	4.54	19.30	23.84	50.00	-26.16	AVG
11	14.0900	10.91	19.42	30.33	60.00	-29.67	QP
12	14.0900	-0.96	19.42	18.46	50.00	-31.54	AVG

Remark:
1. All readings are Quasi-Peak and Average values.
2. Margin = Result (Result =Reading + Factor)–Limit



3.2 RADIATED EMISSION MEASUREMENT

3.2.1 RADIATED EMISSION LIMITS

In any 100 kHz bandwidth outside the operating frequency band. In case the emission fall within the Restricted band specified on Part15.205(a)&209(a) limit in the table and according to ANSI C63.10-2013 below has to be followed

LIMITS OF RADIATED EMISSION MEASUREMENT (0.009MHz - 1000MHz)

Frequencies (MHz)	Field Strength (micorvolts/meter)	Measurement Distance (meters)
0.009~0.490	2400/F(KHz)	300
0.490~1.705	24000/F(KHz)	30
1.705~30.0	30	30
30~88	100	3
88~216	150	3
216~960	200	3
Above 960	500	3

LIMITS OF RADIATED EMISSION MEASUREMENT (1GHz-25 GHz)

FREQUENCY (MHz)	(dBuV/m) (at 3M)	
	PEAK	AVERAGE
Above 1000	74	54

Notes:

(1) The limit for radiated test was performed according to FCC PART 15C.

(2) The tighter limit applies at the band edges.

(3) Emission level (dBuV/m)=20log Emission level (uV/m).

For Radiated Emission

Spectrum Parameter	Setting
Attenuation	Auto
Detector	Peak
Start Frequency	1000 MHz(Peak)
Stop Frequency	10th carrier hamonic(Peak)
RB / VB (emission in restricted band)	PK=1MHz / 1MHz, AV=1 MHz /10 Hz

For Band edge

Spectrum Parameter	Setting
Detector	Peak
Start/Stop Frequency	Lower Band Edge: 2300 to 2403 MHz Upper Band Edge: 2479 to 2500 MHz
RB / VB (emission in restricted band)	PK=1MHz / 1MHz, AV=1 MHz / 10 Hz

Receiver Parameter	Setting
Attenuation	Auto
Start ~ Stop Frequency	9kHz~90kHz / RB 200Hz for PK & AV
Start ~ Stop Frequency	90kHz~110kHz / RB 200Hz for QP
Start ~ Stop Frequency	110kHz~490kHz / RB 200Hz/ 9kHz for PK & AV
Start ~ Stop Frequency	490kHz~30MHz / RB 9kHz for QP
Start ~ Stop Frequency	30MHz~1000MHz / RB 120kHz for QP

3.2.2 TEST PROCEDURE

a. The measuring distance of at 3 m shall be used for measurements at frequency 0.009MHz up to 1GHz,and above 1GHz.
b. The EUT was placed on the top of a rotating table 0.8 meters (above 1GHz is 1.5 m) above the ground at a 3 meter anechoic chamber test site. The table was rotated 360 degrees to determine the position of the highest radiation.
c. The height of the equipment shall be 0.8 m(above 1GHz is 1.5 m); the height of the test antenna shall vary between 1 m to 4 m. horizontal and vertical polarizations of the antenna are set to make the measurement.
d. The initial step in collecting conducted emission data is a spectrum analyzer peak detector mode pre-scanning the measurement frequency range. Significant peaks are then marked and then QuasiPeak detector mode re-measured.
e. If the Peak Mode measured value compliance with and lower than Quasi Peak Mode Limit, the EUT shall be deemed to meet QP Limits and then no additional QP Mode measurement performed.
f. For the actual test configuration, please refer to the related Item –EUT Test Photos.

Note:

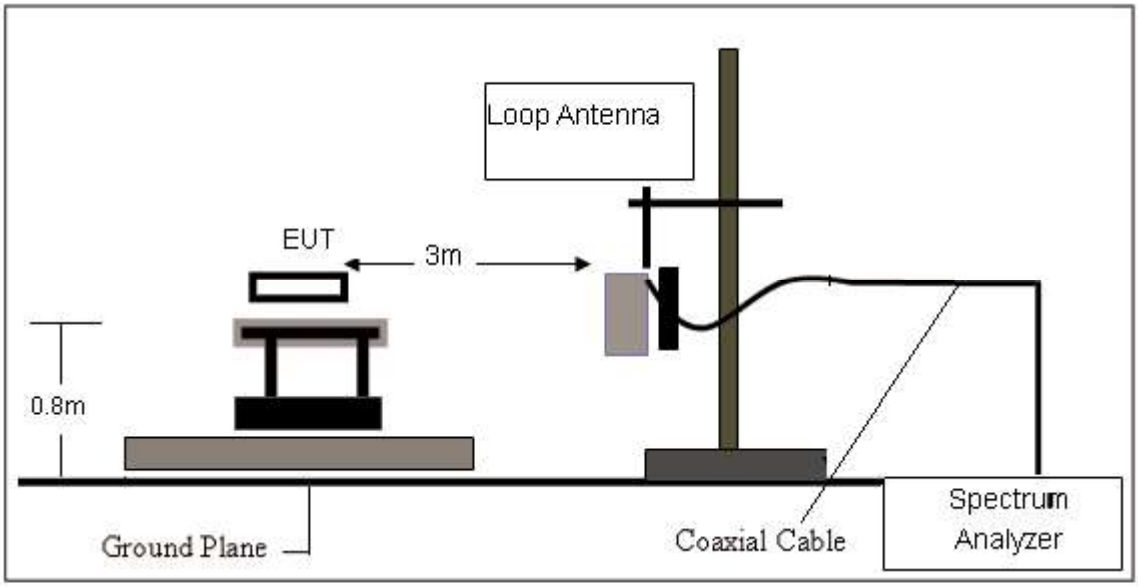
Both horizontal and vertical antenna polarities were tested
and performed pretest to three orthogonal axis. The worst case emissions were reported

3.2.3 DEVIATION FROM TEST STANDARD

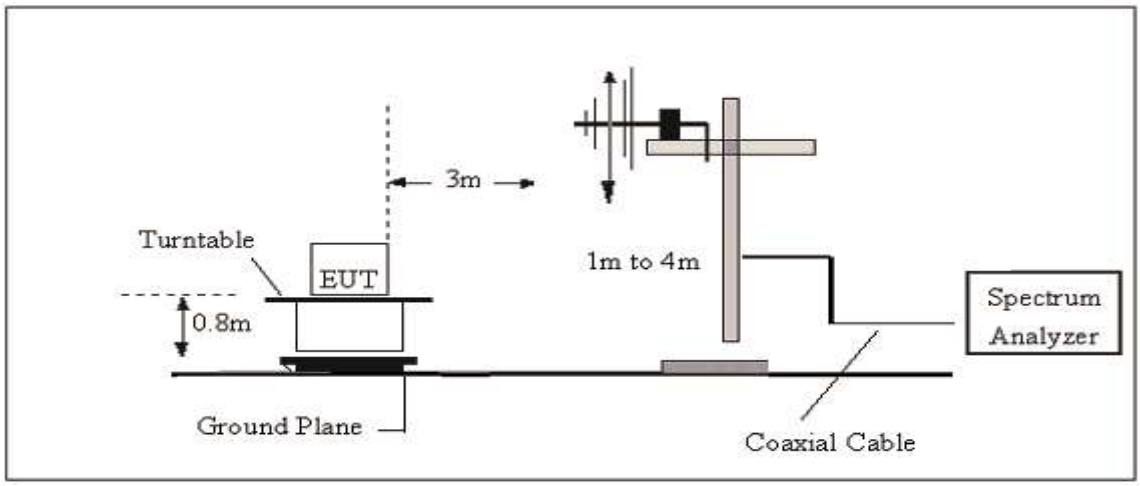
No deviation

3.2.4 TESTSETUP

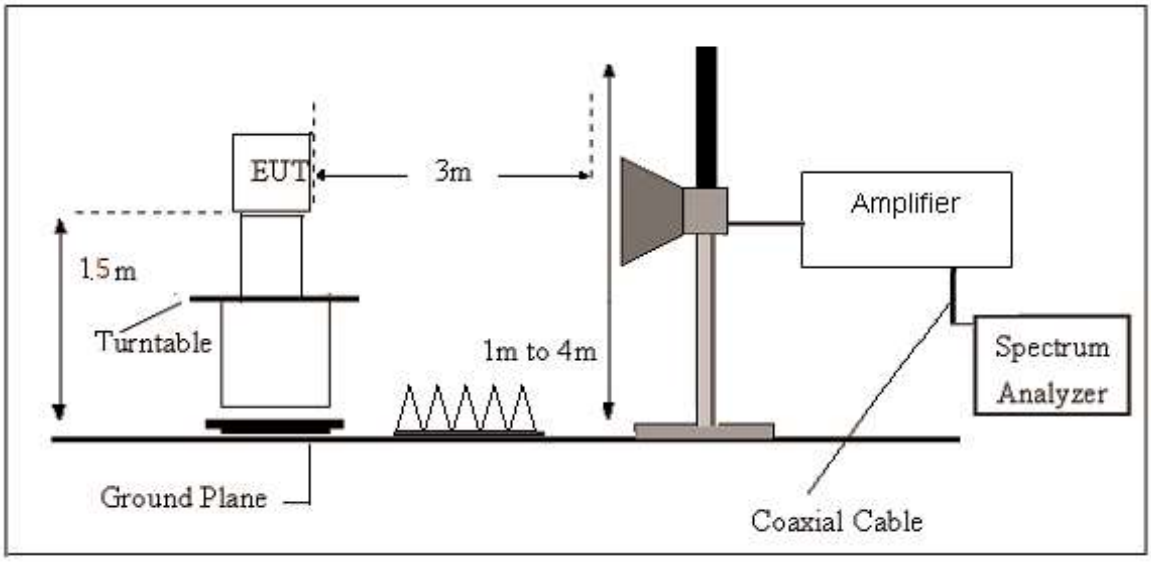
（A）Radiated Emission Test-Up Frequency Below 30MHz



（B）Radiated Emission Test-Up Frequency 30MHz~1GHz



（C）Radiated Emission Test-Up Frequency Above 1GHz



3.2.5 EUT OPERATING CONDITIONS

The EUT tested system was configured as the statements of 2.4 Unless otherwise a special operating condition is specified in the follows during the testing.

1/F., Building B, Zhuoke Science Park, No.190, Chongqing Road, Fuyong Street, Bao'an District, Shenzhen, Guangdong, China
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3.2.6 FIELD STRENGTH CALCULATION

The field strength is calculated by adding the Antenna Factor and Cable Factor and subtracting the Amplifier Gain and Duty Cycle Correction Factor (if any) from the measured reading. The basic equation with a sample calculation is as follows:

FS = RA + AF + CL - AG

Where

FS = Field Strength

CL = Cable Attenuation Factor (Cable Loss)

RA = Reading Amplitude

AG = Amplifier Gain

AF = Antenna Factor

For example

Frequency	FS	RA	AF	CL	AG	Factor
(MHz)	(dBμV/m)	(dBμV/m)	(dB)	(dB)	(dB)	(dB)
300	40	58.1	12.2	1.6	31.9	-18.1

Factor=AF+CL-AG

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3.2.7 TEST RESULTS

(9KHz-30MHz)

Temperature:	24.8(C)	Relative Humidity:	63%RH
Test Voltage:	DC 3.7V	Test Mode:	TX Mode

Freq.	Reading	Limit	Margin	State	Test Result
(MHz)	(dBuV/m)	(dBuV/m)	(dB)	P/F	
--	--	--	--	--	PASS
--	--	--	--	--	PASS

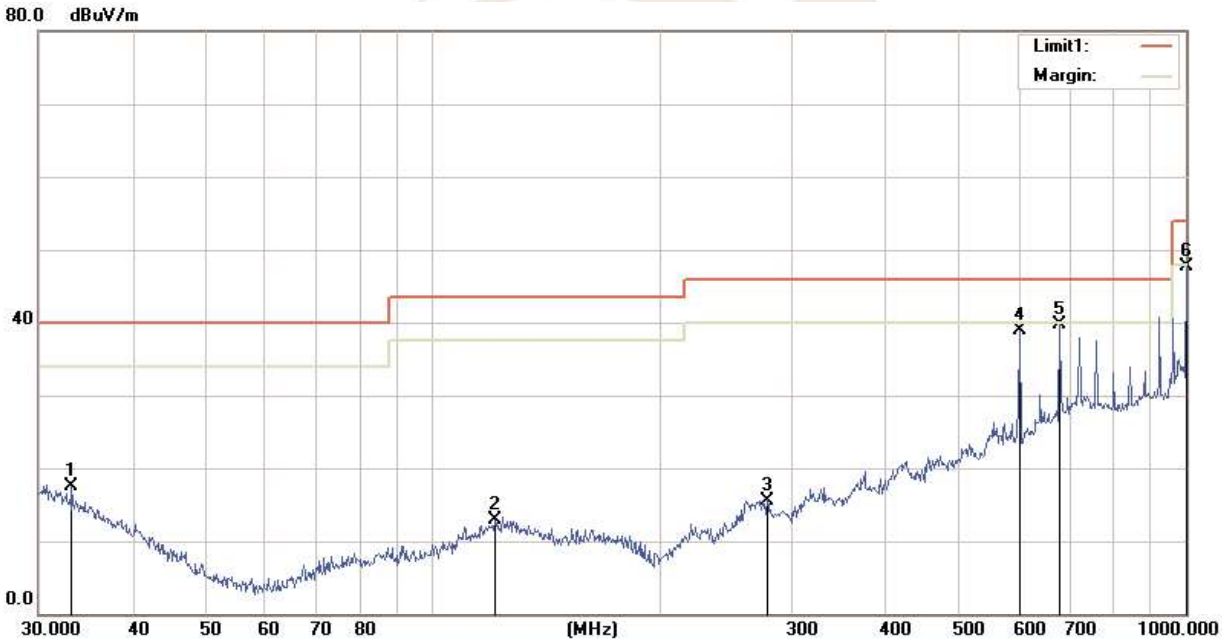
Note:
The amplitude of spurious emissions which are attenuated by more than 20dB below the permissible value has no need to be reported.
Distance extrapolation factor =40 log (specific distance/test distance)(dB);
Limit line = specific limits (dBuv) + distance extrapolation factor.

(30MHz-1000MHz)

Temperature:	24.8(C)	Relative Humidity:	63%RH
Test Voltage:	DC 3.7V	Phase:	Horizontal
Test Mode:	Mode 1/2/3/4/5/6/7/8/9 (Mode 7 worst mode)		

No.	Frequency (MHz)	Reading (dBuV)	Correct Factor(dB/m)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Remark
1	33.2111	31.91	-14.48	17.43	40.00	-22.57	QP
2	121.1230	31.30	-18.32	12.98	43.50	-30.52	QP
3	278.0668	31.15	-15.55	15.60	46.00	-30.40	QP
4	601.4265	44.72	-5.80	38.92	46.00	-7.08	QP
5	679.9600	44.00	-4.28	39.72	46.00	-6.28	QP
6	1000.0000	45.74	2.04	47.78	54.00	-6.22	QP

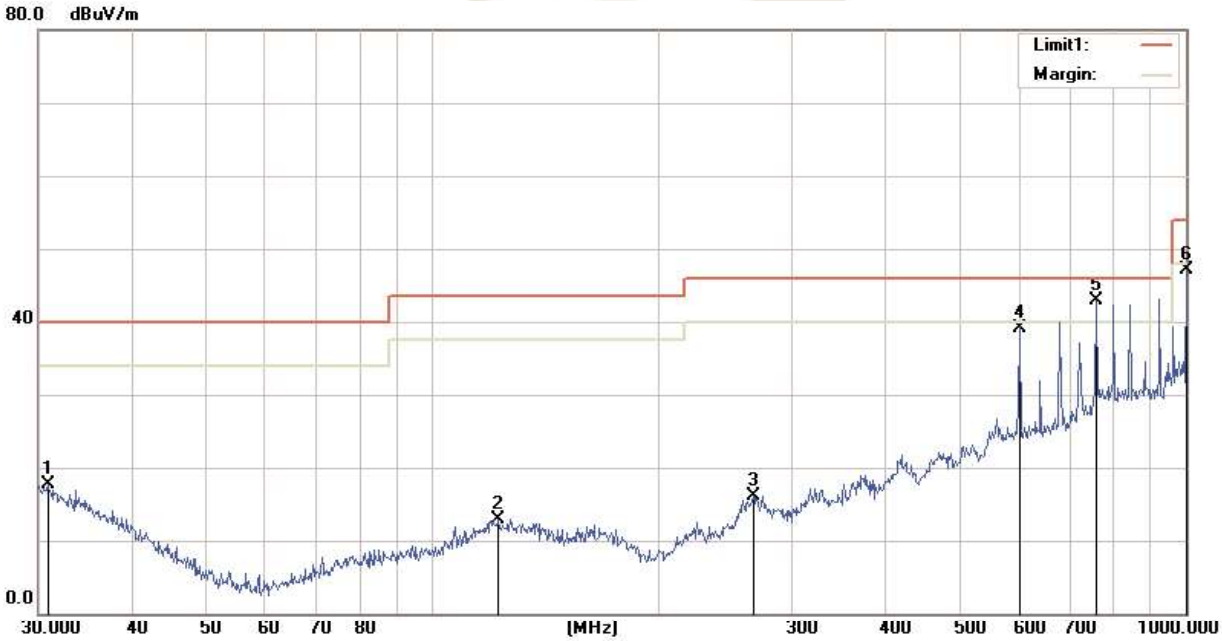
Remark:
1. Margin = Result (Result =Reading + Factor)–Limit



Temperature:	24.8(C)	Relative Humidity:	63%RH
Test Voltage:	DC 3.7V	Phase:	Vertical
Test Mode:	Mode 1/2/3/4/5/6/7/8/9 (Mode 7 worst mode)		

No.	Frequency (MHz)	Reading (dBuV)	Correct Factor(dB/m)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Remark
1	30.8535	30.90	-13.29	17.61	40.00	-22.39	QP
2	122.4040	31.26	-18.29	12.97	43.50	-30.53	QP
3	266.6090	31.09	-14.94	16.15	46.00	-29.85	QP
4	601.4265	45.00	-5.80	39.20	46.00	-6.80	QP
5	760.7036	45.02	-2.18	42.84	46.00	-3.16	QP
6	1000.0000	45.03	2.04	47.07	54.00	-6.93	QP

Remark:
1. Margin = Result (Result =Reading + Factor)–Limit



(1GHz~25GHz) Restricted band and Spurious emission Requirements

Frequency (MHz)	Meter Reading (dBμV)	Amplifier (dB)	Loss (dB)	Antenna Factor (dB/m)	Orrected Factor (dB)	Emission Level (dBμV/m)	Limits (dBμV/m)	Margin (dB)	Detector Type	Comment
Low Channel (2402 MHz)										
3264.71	61.12	44.70	6.70	28.20	-9.80	51.32	74.00	-22.68	PK	Vertical
3264.71	50.26	44.70	6.70	28.20	-9.80	40.46	54.00	-13.54	AV	Vertical
3264.59	61.50	44.70	6.70	28.20	-9.80	51.70	74.00	-22.30	PK	Horizontal
3264.59	50.66	44.70	6.70	28.20	-9.80	40.86	54.00	-13.14	AV	Horizontal
4804.36	58.57	44.20	9.04	31.60	-3.56	55.01	74.00	-18.99	PK	Vertical
4804.36	49.98	44.20	9.04	31.60	-3.56	46.42	54.00	-7.58	AV	Vertical
4804.49	59.46	44.20	9.04	31.60	-3.56	55.90	74.00	-18.10	PK	Horizontal
4804.49	49.49	44.20	9.04	31.60	-3.56	45.93	54.00	-8.07	AV	Horizontal
5359.60	48.67	44.20	9.86	32.00	-2.34	46.33	74.00	-27.67	PK	Vertical
5359.60	40.37	44.20	9.86	32.00	-2.34	38.03	54.00	-15.97	AV	Vertical
5359.60	47.46	44.20	9.86	32.00	-2.34	45.12	74.00	-28.88	PK	Horizontal
5359.60	38.34	44.20	9.86	32.00	-2.34	36.00	54.00	-18.00	AV	Horizontal
7205.76	54.23	43.50	11.40	35.50	3.40	57.63	74.00	-16.37	PK	Vertical
7205.76	44.46	43.50	11.40	35.50	3.40	47.86	54.00	-6.14	AV	Vertical
7205.71	54.94	43.50	11.40	35.50	3.40	58.34	74.00	-15.66	PK	Horizontal
7205.71	44.95	43.50	11.40	35.50	3.40	48.35	54.00	-5.65	AV	Horizontal
Middle Channel (2441 MHz)										
3264.79	61.33	44.70	6.70	28.20	-9.80	51.53	74.00	-22.47	PK	Vertical
3264.79	51.07	44.70	6.70	28.20	-9.80	41.27	54.00	-12.73	AV	Vertical
3264.77	61.15	44.70	6.70	28.20	-9.80	51.35	74.00	-22.65	PK	Horizontal
3264.77	49.87	44.70	6.70	28.20	-9.80	40.07	54.00	-13.93	AV	Horizontal
4882.46	59.41	44.20	9.04	31.60	-3.56	55.85	74.00	-18.15	PK	Vertical
4882.46	49.47	44.20	9.04	31.60	-3.56	45.91	54.00	-8.09	AV	Vertical
4882.32	58.72	44.20	9.04	31.60	-3.56	55.16	74.00	-18.84	PK	Horizontal
4882.32	49.47	44.20	9.04	31.60	-3.56	45.91	54.00	-8.09	AV	Horizontal
5359.69	49.29	44.20	9.86	32.00	-2.34	46.95	74.00	-27.05	PK	Vertical
5359.69	40.15	44.20	9.86	32.00	-2.34	37.81	54.00	-16.19	AV	Vertical
5359.84	47.76	44.20	9.86	32.00	-2.34	45.42	74.00	-28.58	PK	Horizontal
5359.84	38.11	44.20	9.86	32.00	-2.34	35.77	54.00	-18.23	AV	Horizontal
7323.84	54.64	43.50	11.40	35.50	3.40	58.04	74.00	-15.96	PK	Vertical
7323.84	44.41	43.50	11.40	35.50	3.40	47.81	54.00	-6.19	AV	Vertical
7323.69	54.10	43.50	11.40	35.50	3.40	57.50	74.00	-16.50	PK	Horizontal
7323.69	44.91	43.50	11.40	35.50	3.40	48.31	54.00	-5.69	AV	Horizontal

High Channel (2480 MHz)										
3264.66	61.69	44.70	6.70	28.20	-9.80	51.89	74.00	-22.11	PK	Vertical
3264.66	50.03	44.70	6.70	28.20	-9.80	40.23	54.00	-13.77	AV	Vertical
3264.83	62.04	44.70	6.70	28.20	-9.80	52.24	74.00	-21.76	PK	Horizontal
3264.83	50.90	44.70	6.70	28.20	-9.80	41.10	54.00	-12.90	AV	Horizontal
4960.43	58.25	44.20	9.04	31.60	-3.56	54.69	74.00	-19.31	PK	Vertical
4960.43	50.08	44.20	9.04	31.60	-3.56	46.52	54.00	-7.48	AV	Vertical
4960.57	58.43	44.20	9.04	31.60	-3.56	54.87	74.00	-19.13	PK	Horizontal
4960.57	49.38	44.20	9.04	31.60	-3.56	45.82	54.00	-8.18	AV	Horizontal
5359.64	49.12	44.20	9.86	32.00	-2.34	46.78	74.00	-27.22	PK	Vertical
5359.64	39.05	44.20	9.86	32.00	-2.34	36.71	54.00	-17.29	AV	Vertical
5359.84	47.66	44.20	9.86	32.00	-2.34	45.32	74.00	-28.68	PK	Horizontal
5359.84	38.54	44.20	9.86	32.00	-2.34	36.20	54.00	-17.80	AV	Horizontal
7439.95	54.35	43.50	11.40	35.50	3.40	57.75	74.00	-16.25	PK	Vertical
7439.95	44.81	43.50	11.40	35.50	3.40	48.21	54.00	-5.79	AV	Vertical
7439.93	53.55	43.50	11.40	35.50	3.40	56.95	74.00	-17.05	PK	Horizontal
7439.93	43.90	43.50	11.40	35.50	3.40	47.30	54.00	-6.70	AV	Horizontal

Note:

1) Scan with GFSK, π/4-DQPSK,8DPSK,the worst case is GFSK Mode

2) Factor = Antenna Factor + Cable Loss – Pre-amplifier.

Emission Level = Reading + Factor

3) The frequency emission of peak points that did not show above the forms are at least 20dB below the limit, the frequency emission is mainly from the environment noise.

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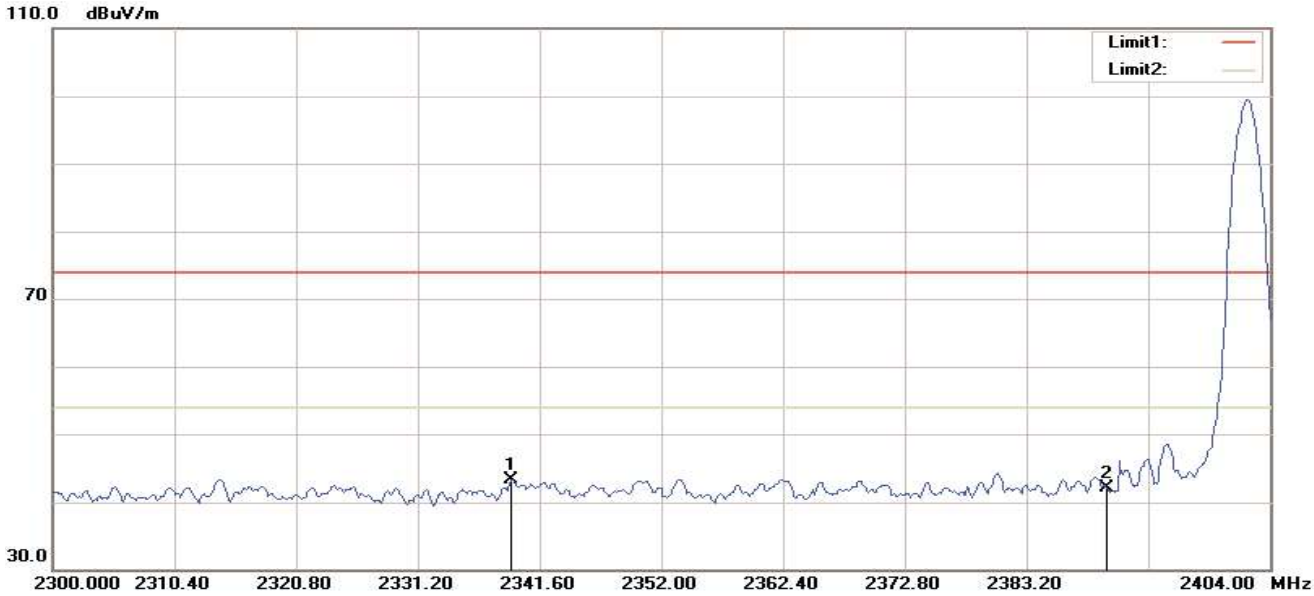
Restricted band Requirements

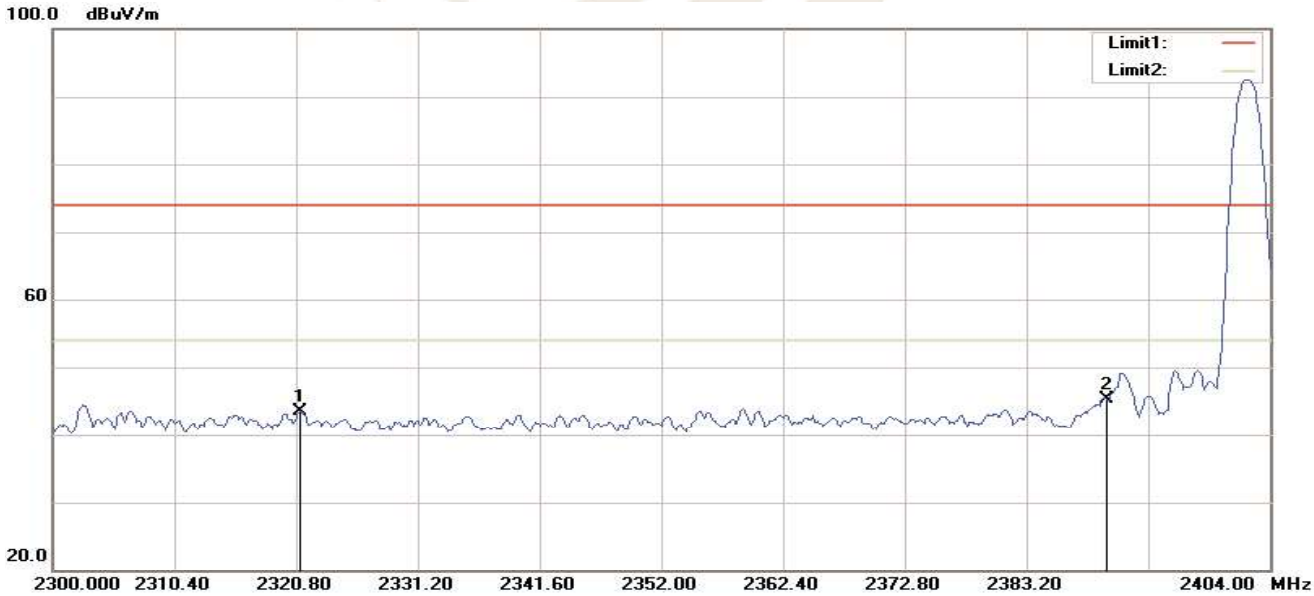
GFSK-Low

Horizontal



No.	Frequency (MHz)	Reading (dBuV)	Correct Factor(dB/m)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Remark
1	2339.208	39.59	3.68	43.27	74.00	-30.73	peak
2	2390.000	37.79	4.34	42.13	74.00	-31.87	peak

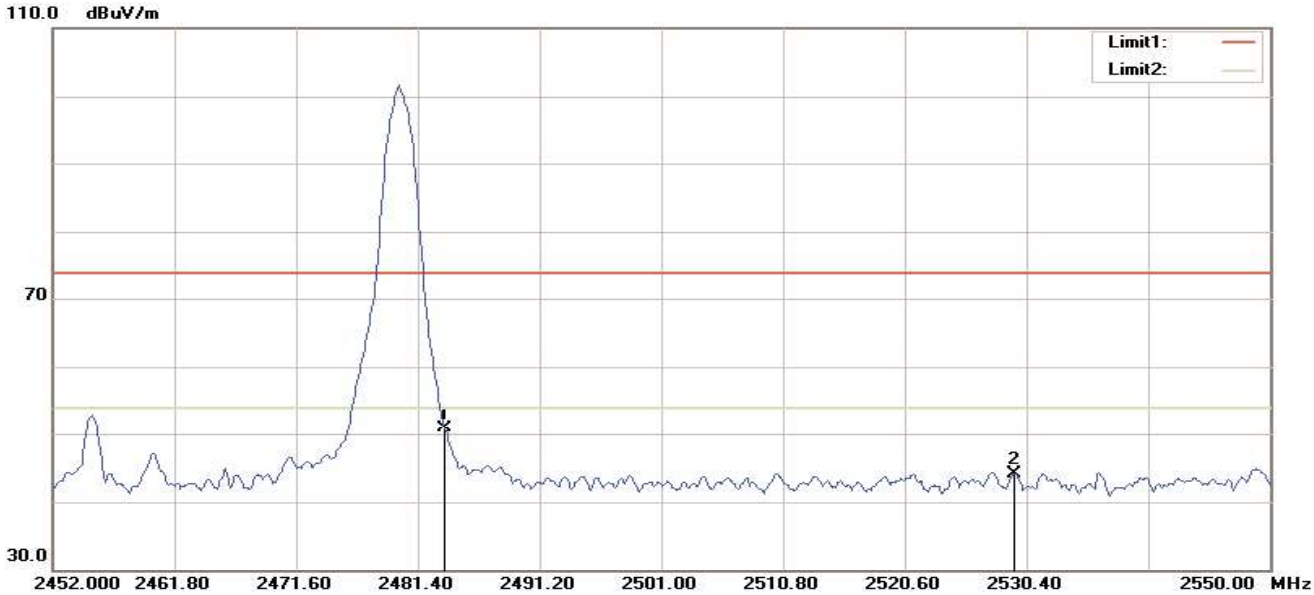
Vertical



No.	Frequency (MHz)	Reading (dBuV)	Correct Factor(dB/m)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Remark
1	2321.112	39.91	3.58	43.49	74.00	-30.51	peak
2	2390.000	41.03	4.34	45.37	74.00	-28.63	peak

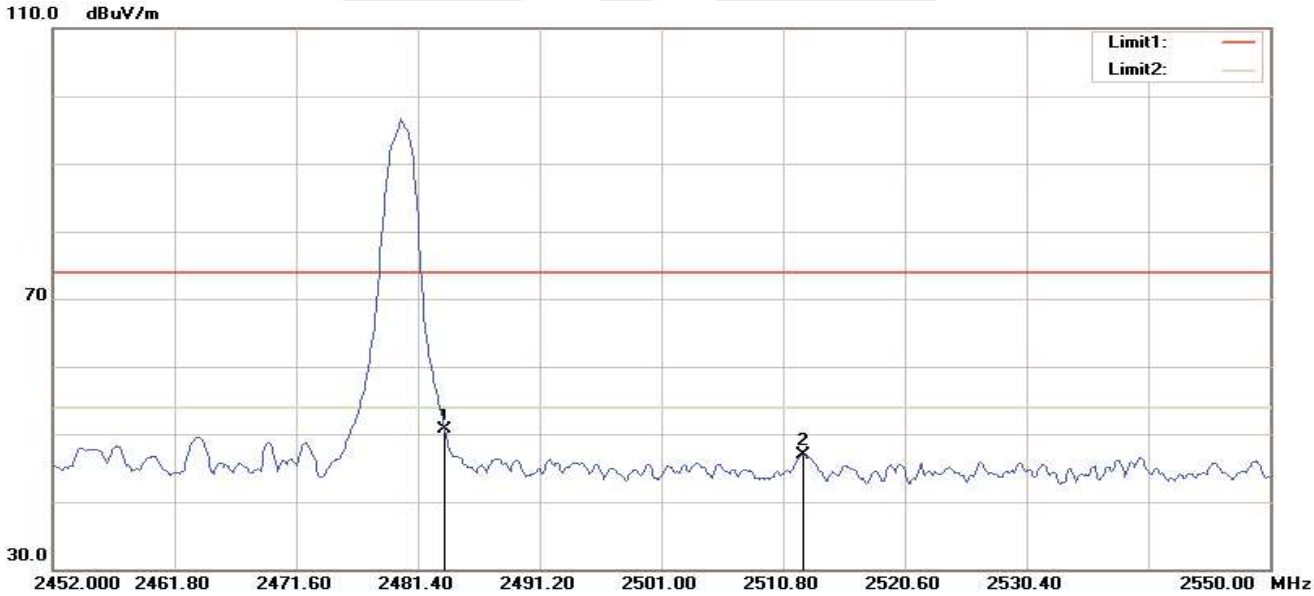
GFSK-High

Horizontal



No.	Frequency (MHz)	Reading (dBuV)	Correct Factor(dB/m)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Remark
1	2483.500	46.39	4.60	50.99	74.00	-23.01	peak
2	2529.420	39.31	4.85	44.16	74.00	-29.84	peak

Vertical



No.	Frequency (MHz)	Reading (dBuV)	Correct Factor(dB/m)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Remark
1	2483.500	46.03	4.60	50.63	74.00	-23.37	peak
2	2512.368	42.20	4.73	46.93	74.00	-27.07	peak

Note: GFSK, π/4-DQPSK, 8DPSK of the nohopping and hopping mode all have been test, the worst case is GFSK of the nohopping mode, this report only show the worst case.

4. CONDUCTED SPURIOUS & BAND EDGE EMISSION

4.1 LIMIT

According to FCC section 15.247(d), in any 100kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20dB below that in the 100kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement.

4.2 TEST PROCEDURE

Spectrum Parameter	Setting
Detector	Peak
Start/Stop Frequency	30 MHz to 10th carrier harmonic
RB / VB (emission in restricted band)	100 KHz/300 KHz
Trace-Mode:	Max hold

.

For Band edge

Spectrum Parameter	Setting
Detector	Peak
Start/Stop Frequency	Lower Band Edge: 2300– 2403 MHz Upper Band Edge: 2479 – 2500 MHz
RB / VB (emission in restricted band)	100 KHz/300 KHz
Trace-Mode:	Max hold

Remark: Hopping on and Hopping off mode all have been tested, only worst case hopping off is reported.

4.3 TEST SETUP

The EUT is connected to the Spectrum Analyzer; the RF load attached to the EUT antenna terminal is 50Ohm; the path loss as the factor is calibrated to correct the reading. Make the measurement with the spectrum analyzer's resolution bandwidth (RBW) = 100 kHz. In order to make an accurate measurement, set the span greater than RBW.

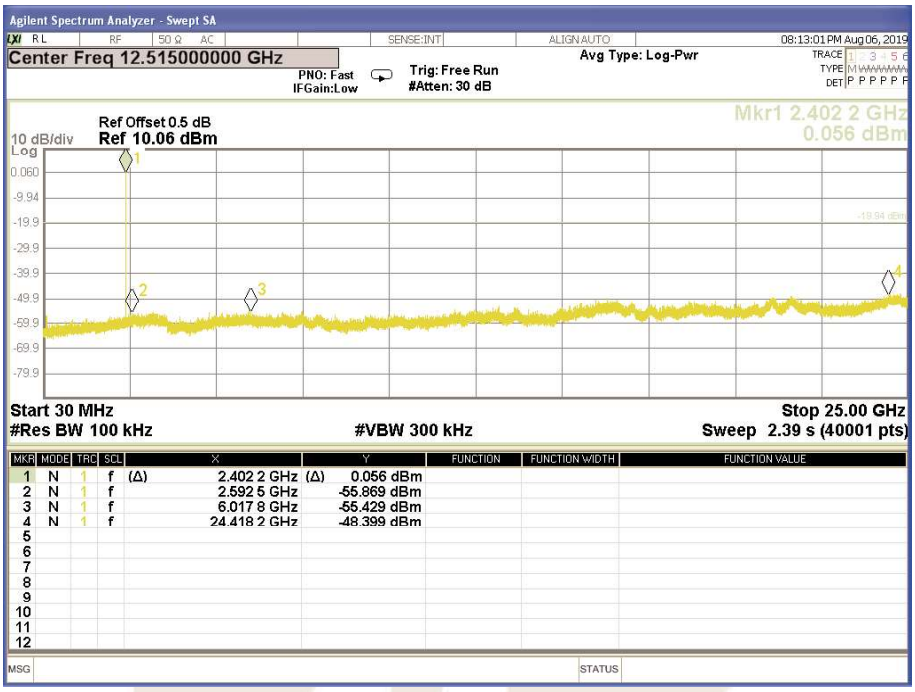
4.4 EUT OPERATION CONDITIONS

The EUT tested system was configured as the statements of 2.3 Unless otherwise a special operating condition is specified in the follows during the testing.

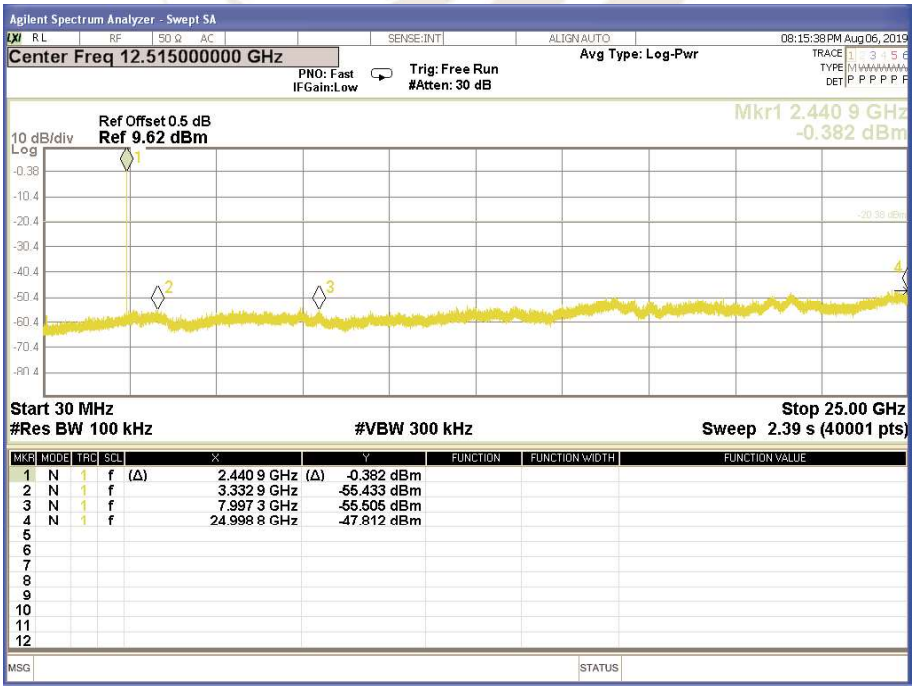
4.5 TEST RESULTS

Temperature:	25℃	Relative Humidity:	50%
Test Mode:	GFSK(1Mbps)-00/39/78 CH	Test Voltage:	DC 3.7V

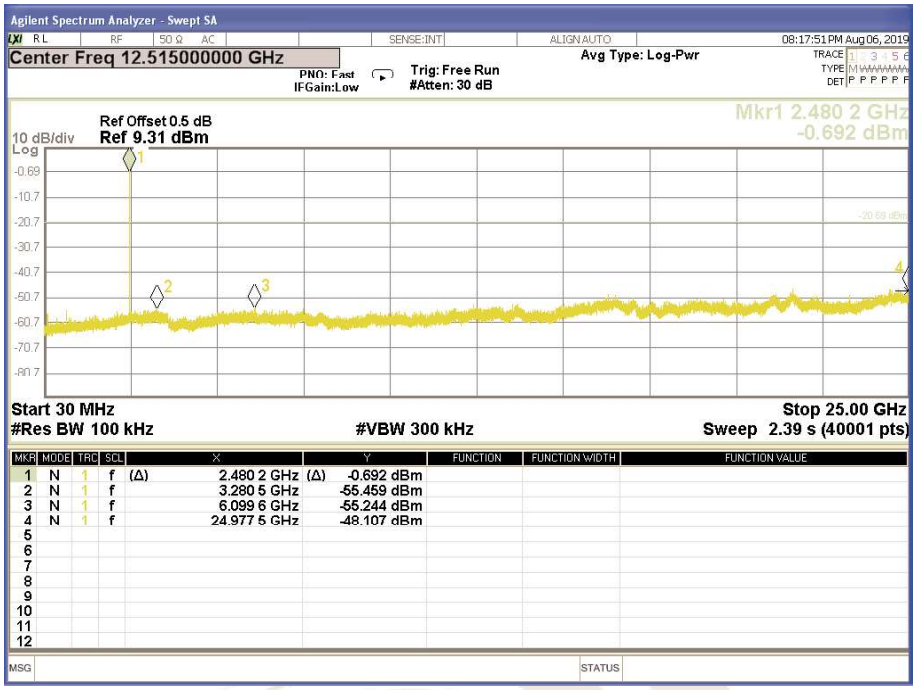
00 CH



39 CH



78 CH


Agilent Spectrum Analyzer - Swept SA
Center Freq 12.515000000 GHz
PNO: Fast
IFGain:Low
Trig: Free Run
#Atten: 30 dB
Avg Type: Log-Pwr
08:17:51 PM Aug 06, 2019
Ref Offset 0.5 dB
10 dB/div
Ref 9.31 dBm
Mkr1 2.480 2 GHz
-0.692 dBm
Start 30 MHz
#Res BW 100 kHz
#VBW 300 kHz
Stop 25.00 GHz
Sweep 2.39 s (40001 pts)
1 N 1 f (Δ) 2.480 2 GHz (Δ) -0.692 dBm
2 N 1 f 3.280 5 GHz -55.459 dBm
3 N 1 f 6.099 6 GHz -55.244 dBm
4 N 1 f 24.977 5 GHz -48.107 dBm

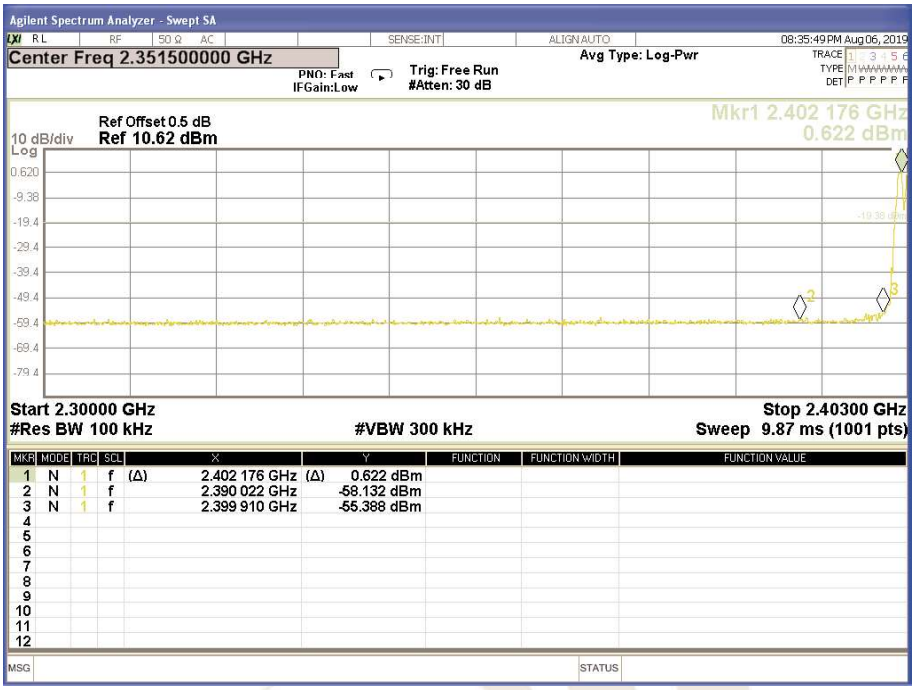
For Band edge

00 CH

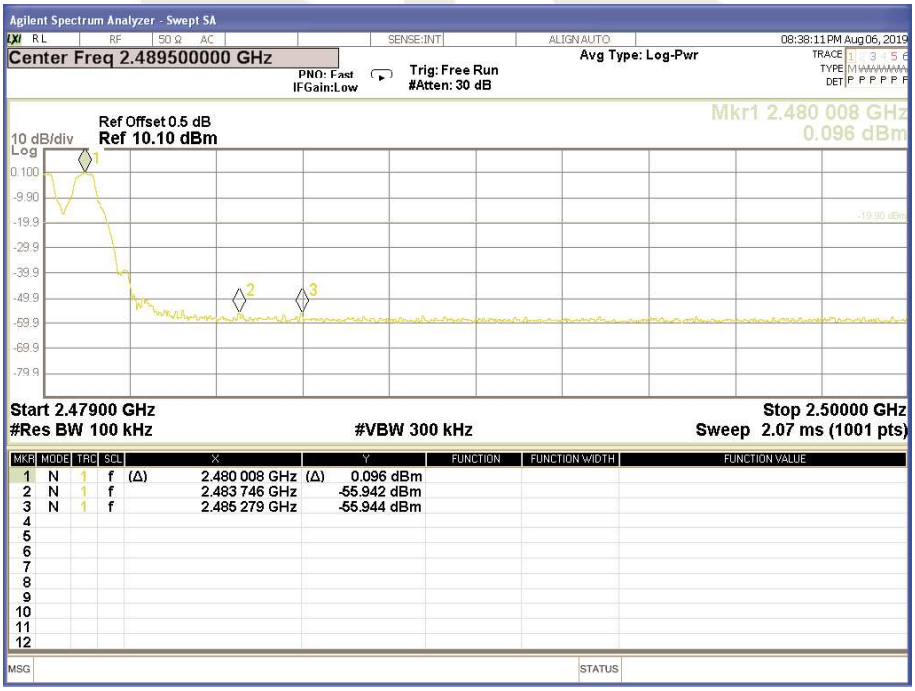
78 CH

For Hopping Band edge

00 CH

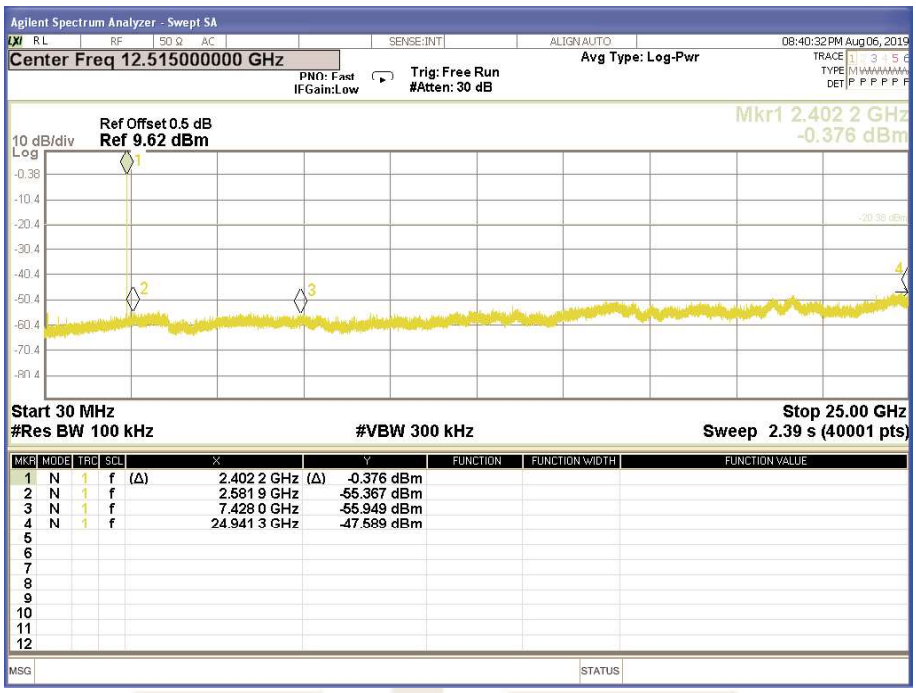


78 CH

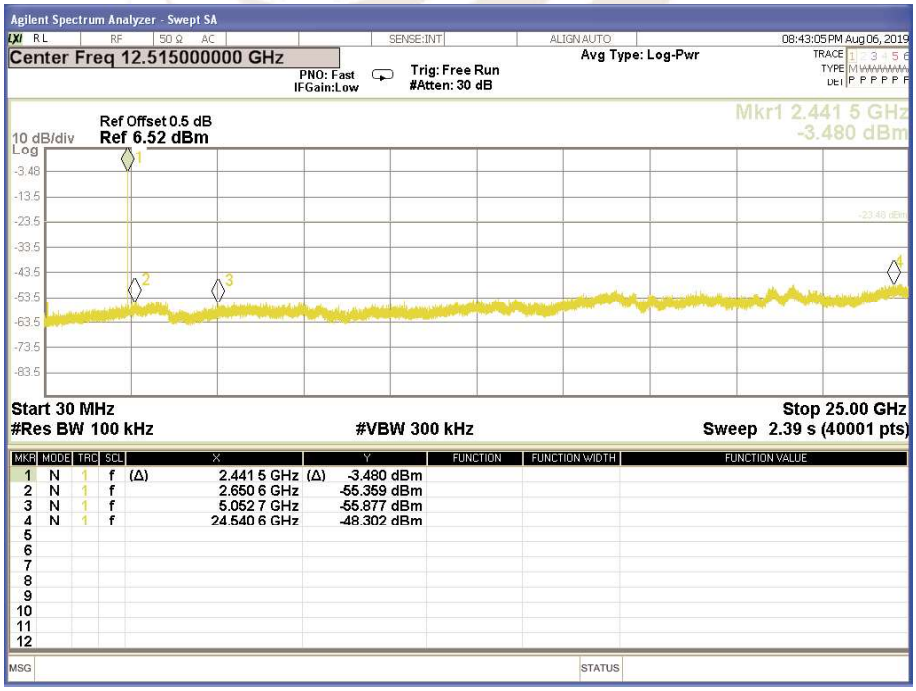


Temperature:	25℃	Relative Humidity:	50%
Test Mode:	π/4-DQPSK(2Mbps)–00/39/78 CH	Test Voltage:	DC 3.7V

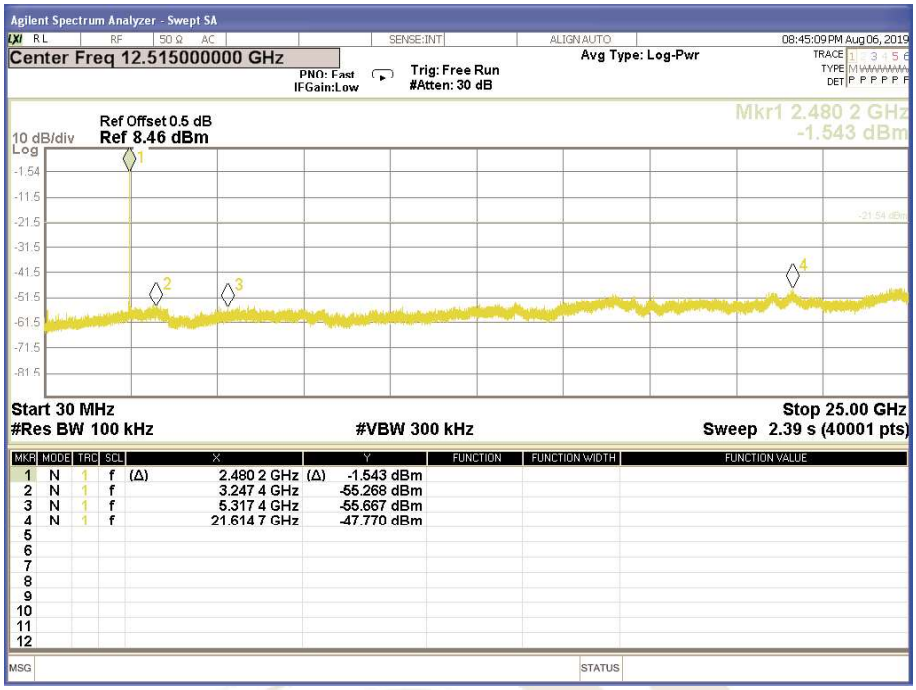
00 CH



39 CH

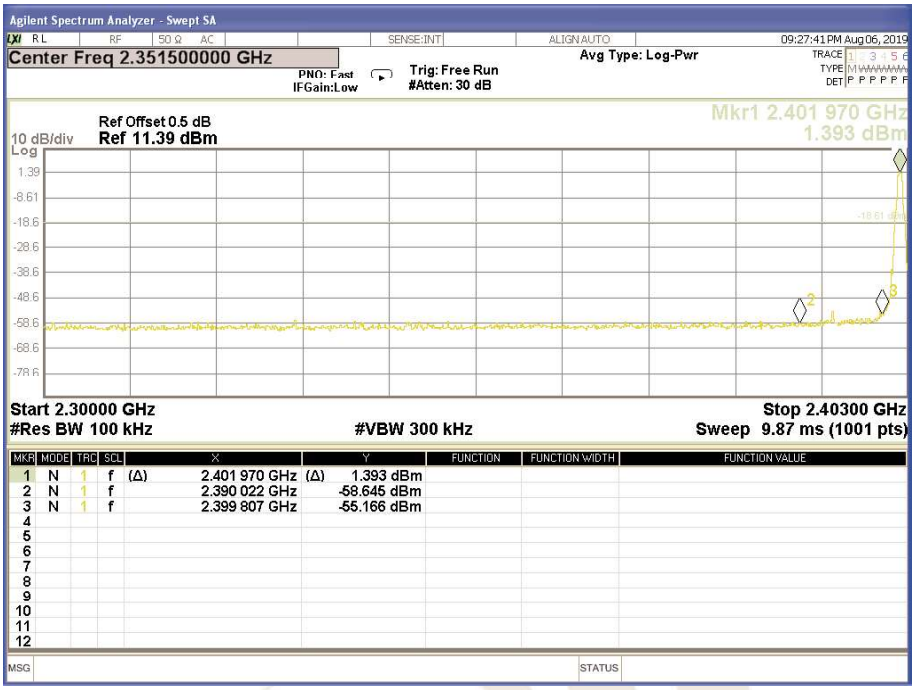


78 CH

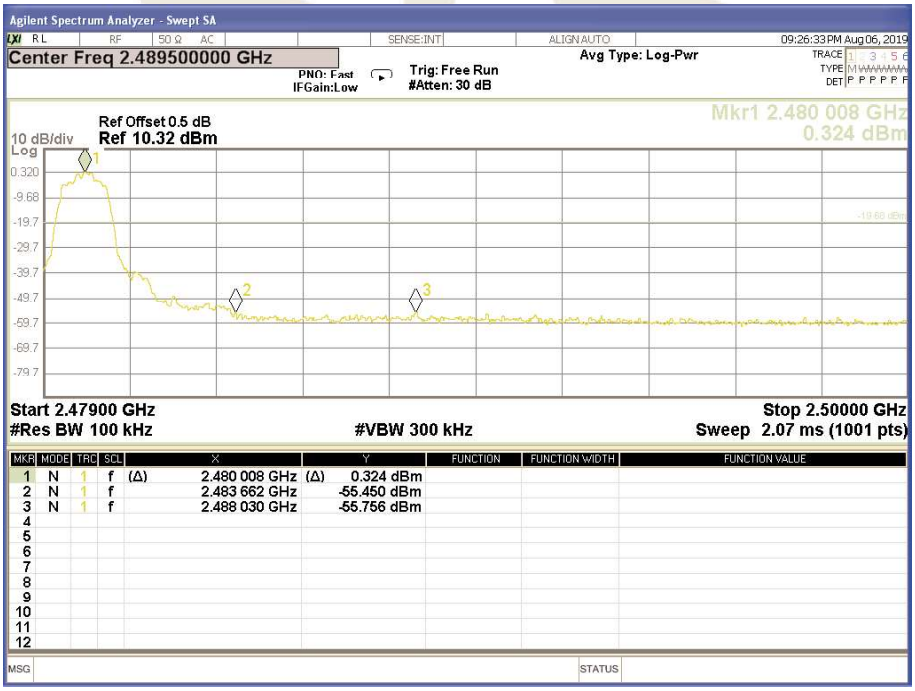

Agilent Spectrum Analyzer - Swept SA
Center Freq 12.515000000 GHz
PNO: Fast
IFGain:Low
Trig: Free Run
#Atten: 30 dB
Avg Type: Log-Pwr
08:45:09 PM Aug 06, 2019
Ref Offset 0.5 dB
10 dB/div
Ref 8.46 dBm
Mkr1 2.480 2 GHz
-1.543 dBm
Start 30 MHz
#Res BW 100 kHz
#VBW 300 kHz
Stop 25.00 GHz
Sweep 2.39 s (40001 pts)
1 N 1 f (Δ) 2.480 2 GHz (Δ) -1.543 dBm
2 N 1 f 3.247 4 GHz -55.268 dBm
3 N 1 f 5.317 4 GHz -55.667 dBm
4 N 1 f 21.614 7 GHz -47.770 dBm

For Band edge

00 CH

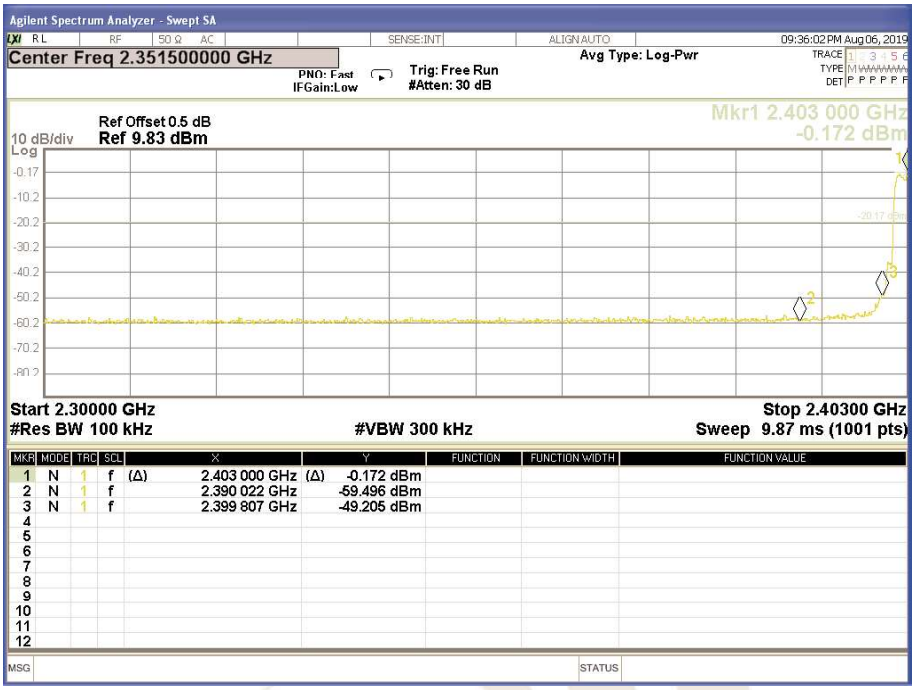


78 CH



For Hopping Band edge

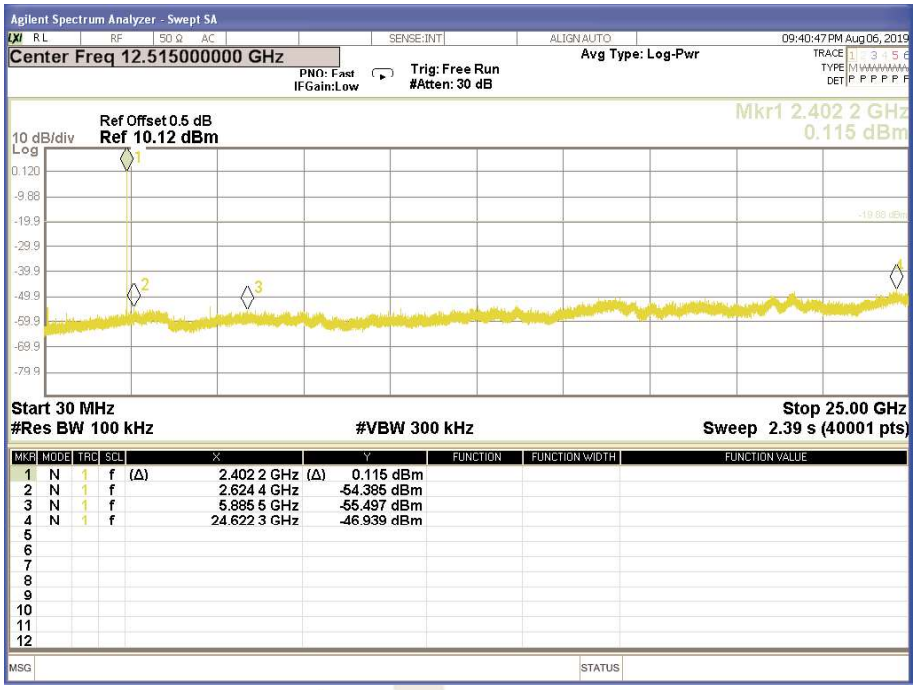
00 CH



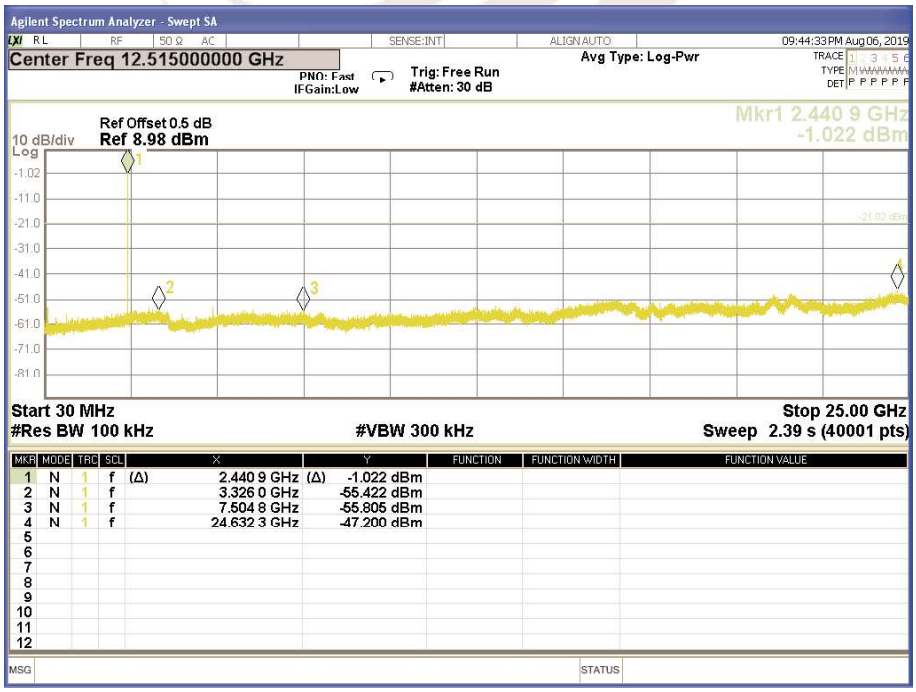
78 CH

Temperature:	25℃	Relative Humidity:	50%
Test Mode:	8DPSK(3Mbps) -00/39/78 CH	Test Voltage:	DC 3.7V

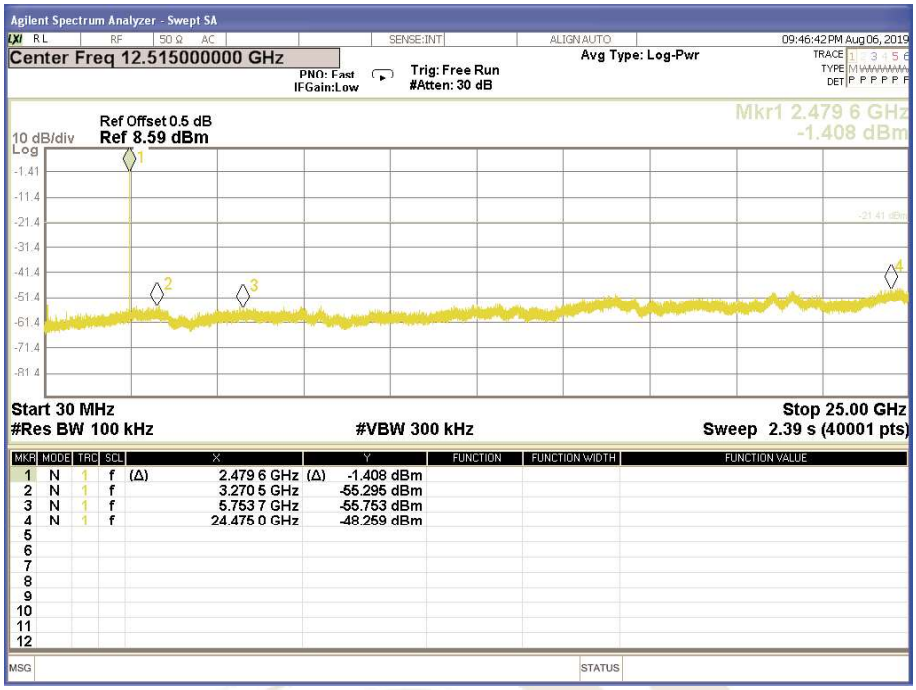
00 CH



39 CH

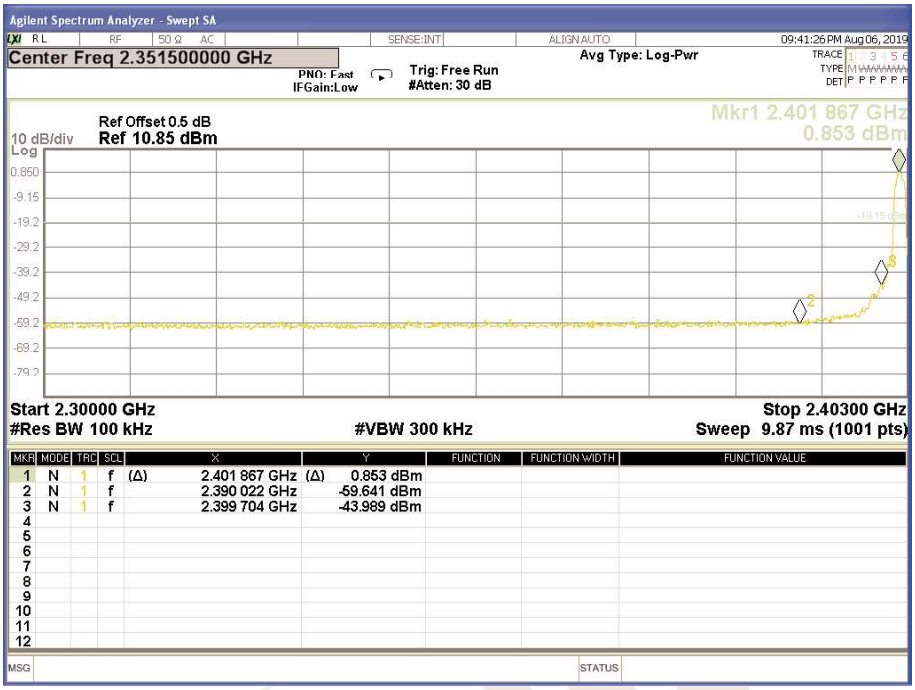


78 CH

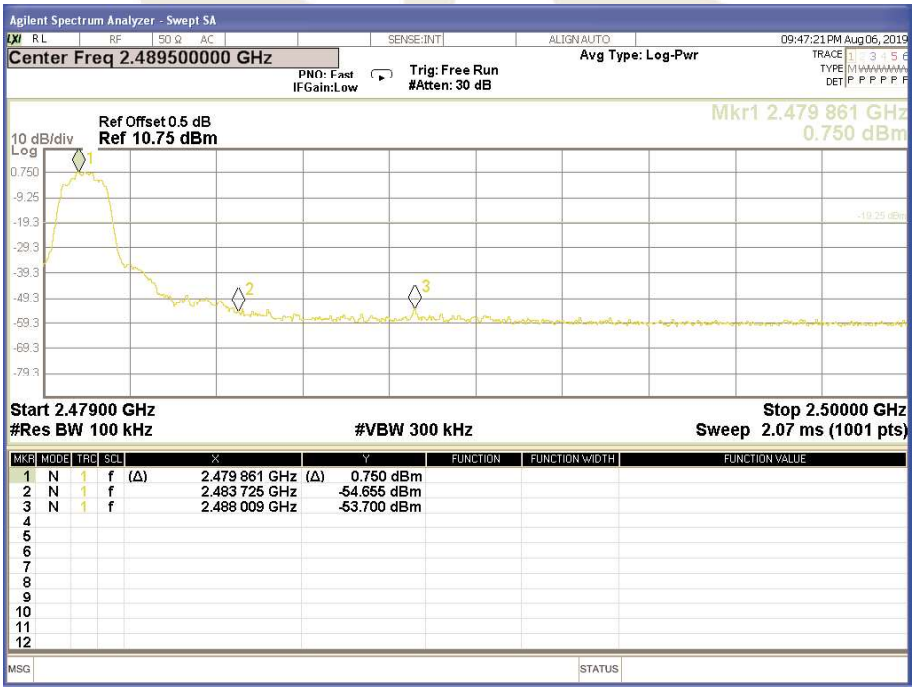

Agilent Spectrum Analyzer - Swept SA
RL
RF
50 Ω AC
SENSE:INT
ALIGN AUTO
09:46:42 PM Aug 06, 2019
Center Freq 12.515000000 GHz
PNO: Fast
IFGain:Low
Trig: Free Run
#Atten: 30 dB
Avg Type: Log-Pwr
TRACE 1 3 4 5 6
TYPE M
DET P P P P P
Ref Offset 0.5 dB
10 dB/div
Ref 8.59 dBm
Log
Mkr1 2.479 6 GHz
-1.408 dBm
-1.41
-11.4
-21.4
-31.4
-41.4
-51.4
-61.4
-71.4
-81.4
Start 30 MHz
#Res BW 100 kHz
#VBW 300 kHz
Stop 25.00 GHz
Sweep 2.39 s (40001 pts)
MKR MODE TRC SCL X Y FUNCTION FUNCTION WIDTH FUNCTION VALUE
1 N 1 f (Δ) 2.479 6 GHz (Δ) -1.408 dBm
2 N 1 f 3.270 5 GHz -55.295 dBm
3 N 1 f 5.753 7 GHz -55.753 dBm
4 N 1 f 24.475 0 GHz -48.259 dBm
5
6
7
8
9
10
11
12
MSG
STATUS

For Band edge

00 CH

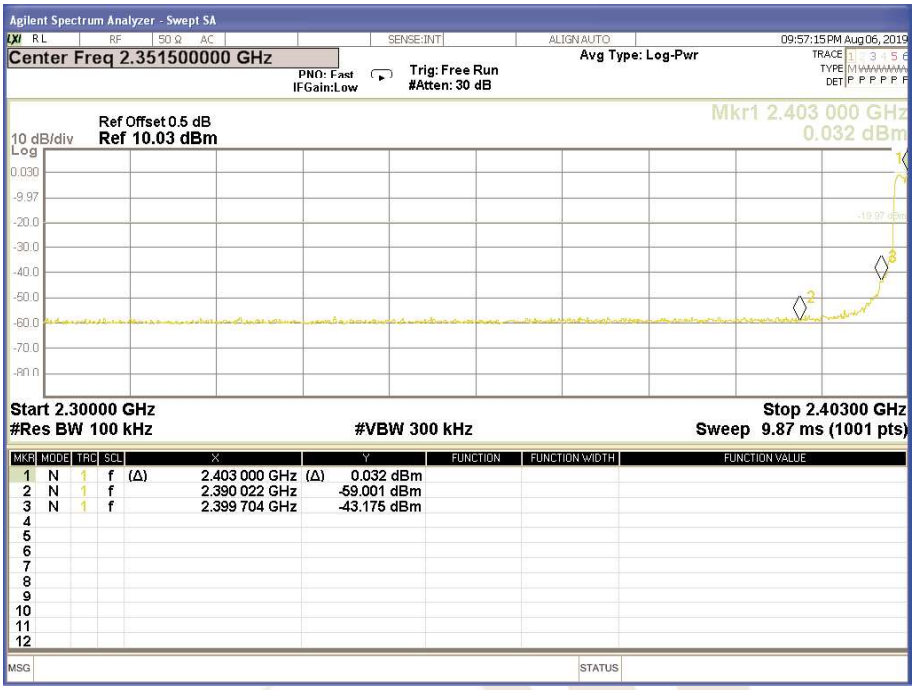


78 CH

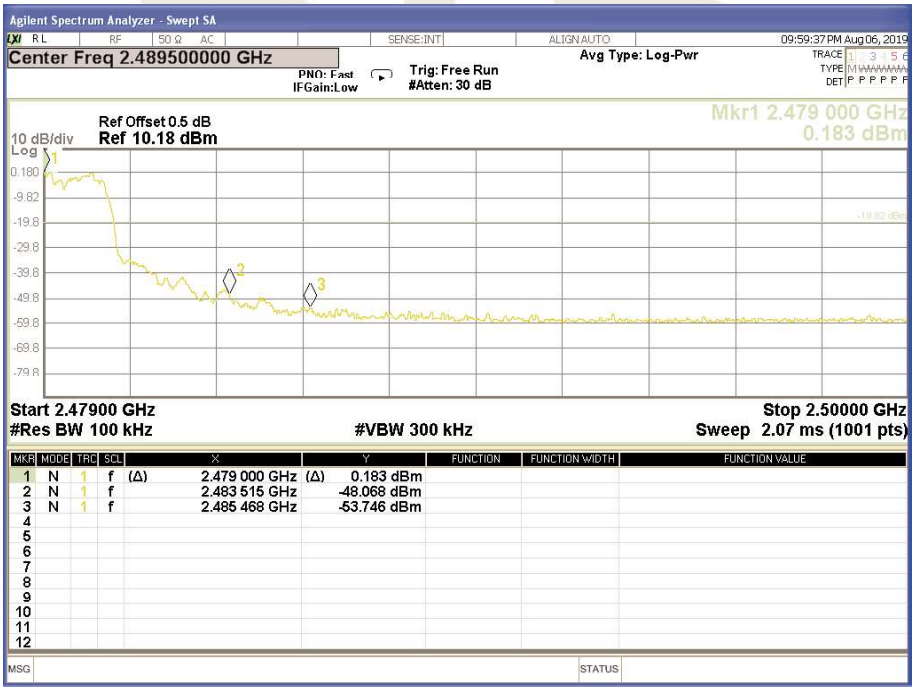


For Hopping Band edge

00 CH



78 CH



5. NUMBER OF HOPPING CHANNEL

5.1 LIMIT

FCC Part 15.247,Subpart C				
Section	Test Item	Limit	FrequencyRange (MHz)	Result
15.247 (a)(1)(iii)	Number of Hopping Channel	≥15	2400-2483.5	PASS

Spectrum Parameters	Setting
Attenuation	Auto
Span Frequency	> Operating FrequencyRange
RB	300KHz
VB	300KHz
Detector	Peak
Trace	Max Hold
Sweep Time	Auto

5.2 TEST PROCEDURE

a. The EUT was directly connected to the spectrum analyzer and antenna output port as show in the block diagram below,

b. Spectrum Setting: RBW= 300KHz, VBW=300KHz, Sweep time = Auto.

5.3 TEST SETUP

5.4 EUT OPERATION CONDITIONS

The EUT tested system was configured as the statements of 2.4 Unless otherwise a special operating condition is specified in the follows during the testing.

5.5 TEST RESULTS

Temperature:	25℃	Relative Humidity:	60%
Test Mode:	Hopping Mode -GFSK Mode	Test Voltage:	DC 3.7V

Number of Hopping Channel 79

Hopping channel

6. AVERAGE TIME OF OCCUPANCY

6.1 LIMIT

FCC Part 15.247,Subpart C				
Section	Test Item	Limit	FrequencyRange (MHz)	Result
15.247 (a)(1)(iii)	Average Time of Occupancy	0.4sec	2400-2483.5	PASS

6.2 TEST PROCEDURE

a. The transmitter output (antenna port) was connected to the spectrum analyzer
b. Set RBW =1MHz/VBW =3MHz.
c. Use a video trigger with the trigger level set to enable triggering only on full pulses.
d. Sweep Time is more than once pulse time.
e. Set the center frequency on any frequency would be measure and set the frequency span to zero span.
f. Measure the maximum time duration of one single pulse.
g. Set the EUT for DH5, DH3 and DH1 packet transmitting.
h. Measure the maximum time duration of one single pulse.
i. DH5 Packet permit maximum 1600/ 79 / 6 = 3.37 hops per second in each channel (5 time slots RX, 1 time slot TX). Sothe dwell time is the time duration of the pulse times 3.37 x 31.6 = 106.6 within 31.6 seconds.
j. DH3 Packet permit maximum 1600 / 79 / 4 = 5.06 hops per second in each channel (3 time slots RX, 1 time slot TX). Sothe dwell time is the time duration of the pulse times 5.06 x 31.6 = 160 within 31.6 seconds.
k. DH1 Packet permit maximum 1600 / 79 /2 = 10.12 hops per second in each channel (1 time slot RX, 1 time slot TX). So the dwell time is the time duration of the pulse times 10.12 x 31.6 = 320 within 31.6 seconds.

6.3 TEST SETUP

6.4 EUT OPERATION CONDITIONS

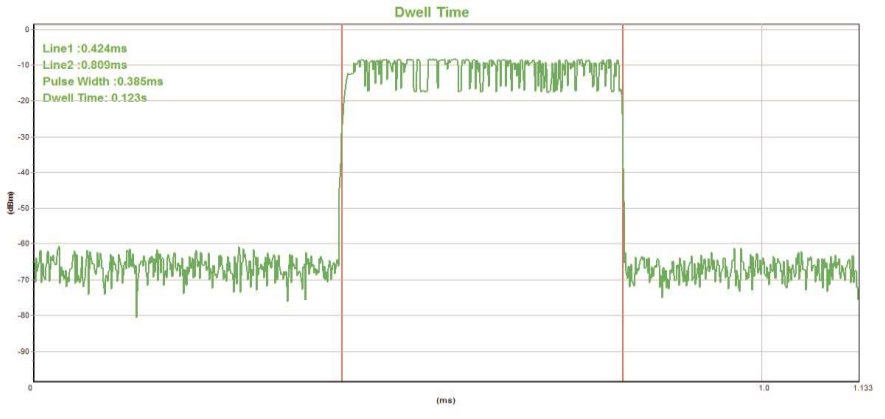
The EUT tested system was configured as the statements of 2.4 Unless otherwise a special operating condition is specified in the follows during the testing.

6.5 TEST RESULTS

Temperature:	25℃	Relative Humidity:	50%
Test Mode:	GFSK(1Mbps)-DH1/DH3/DH5	Test Voltage:	DC 3.7V

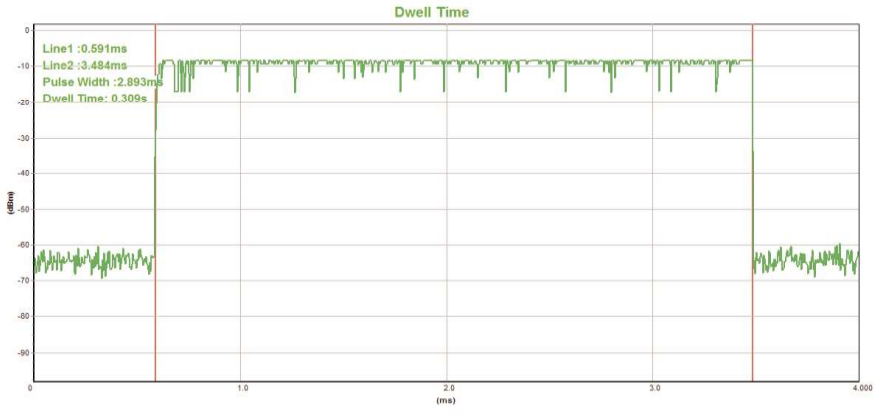
Data Packet	Channel	pulse time(ms)	Dwell Time(s)	Limits(s)
DH1	middle	0.385	0.123	0.4
DH3	middle	1.645	0.263	0.4
DH5	middle	2.893	0.309	0.4

CH39-DH1



CH39-DH3

CH39-DH5

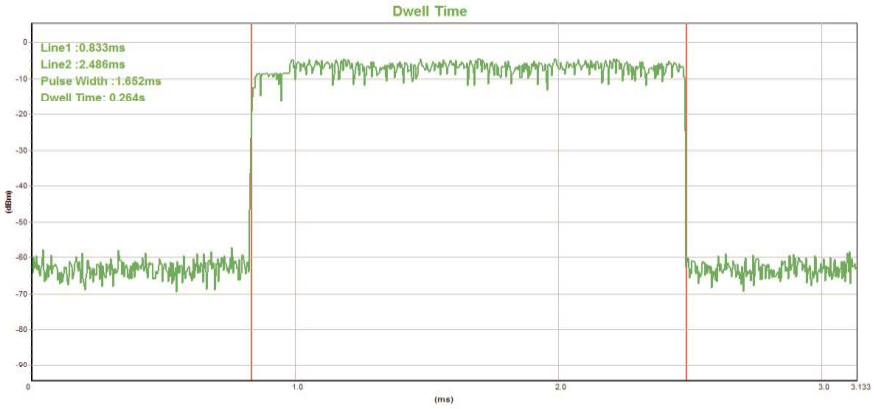


Temperature:	25℃	Relative Humidity:	50%
Test Mode:	π/4-DQPSK(2Mbps)–2DH1/2DH3/2DH5	Test Voltage:	DC 3.7V

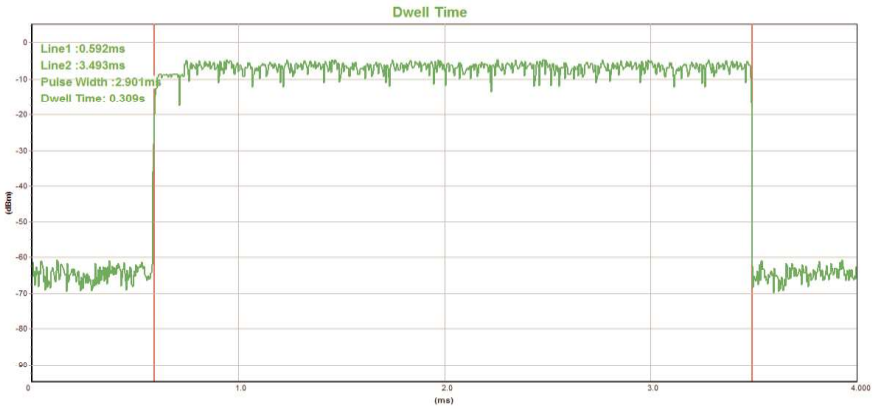
Data Packet	Channel	pulse time(ms)	Dwell Time(s)	Limits(s)
2DH1	middle	0.397	0.127	0.4
2DH3	middle	1.652	0.264	0.4
2DH5	middle	2.901	0.309	0.4

CH39-2DH1

CH39-2DH3



CH39-2DH5

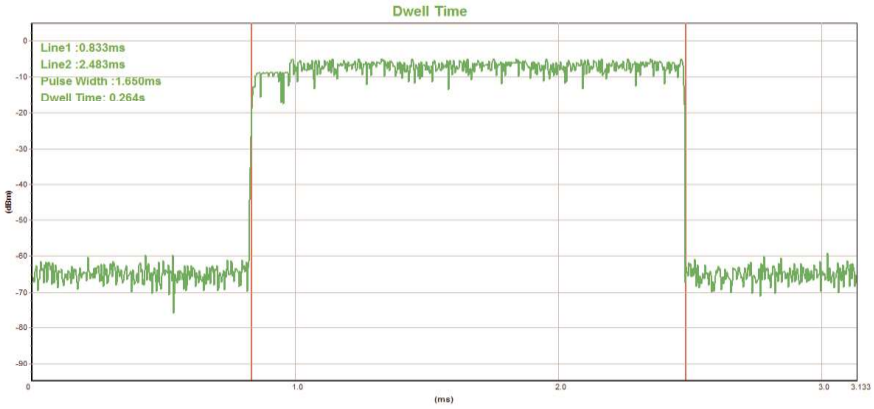


Temperature:	25℃	Relative Humidity:	50%
Test Mode:	8DPSK(3Mbps)– 3DH1/3DH3/3DH5	Test Voltage:	DC 3.7V

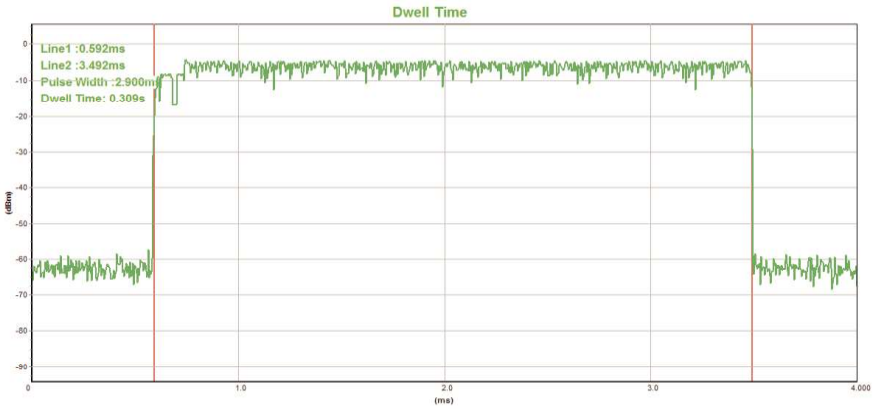
Data Packet	Channel	pulse time(ms)	Dwell Time(s)	Limits(s)
3DH1	middle	0.397	0.127	0.4
3DH3	middle	1.650	0.264	0.4
3DH5	middle	2.900	0.309	0.4

CH39-3DH1

CH39-3DH3



CH39-3DH5



7. HOPPING CHANNEL SEPARATION MEASUREMEN

7.1 LIMIT

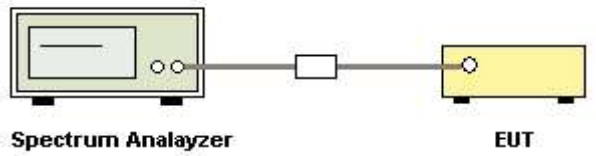
Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, frequency hopping systems operating in the 2400-2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW.

Spectrum Parameter	Setting
Attenuation	Auto
Span Frequency	> 20 dB Bandwidth or Channel Separation
RB	30 kHz (20dB Bandwidth) / 30 kHz (Channel Separation)
VB	100 kHz (20dB Bandwidth) / 100 kHz (Channel Separation)
Detector	Peak
Trace	Max Hold
Sweep Time	Auto

7.2 TEST PROCEDURE

a. The transmitter output (antenna port) was connected to the spectrum analyser in peak hold mode.
b. The resolution bandwidth of 30 kHz and the video bandwidth of 100 kHz were utilised for 20 dB bandwidth measurement.
c. The resolution bandwidth of 30 kHz and the video bandwidth of 100 kHz were utilised for channel separation measurement.

7.3 TEST SETUP



7.4 EUT OPERATION CONDITIONS

The EUT was programmed to be in continuously transmitting mode.

7.5 TEST RESULTS

Temperature:	25℃	Relative Humidity:	50%
Test Mode:	CH00 / CH39 / CH78 (GFSK(1Mbps) Mode)	Test Voltage:	DC 3.7V

Frequency	Mark1 Frequency （MHz）	Mark2 Frequency （MHz）	Ch. Separation (MHz)	Limit (MHz)	Result
2402 MHz	2401.837	2402.836	0.999	0.922	Complies
2441 MHz	2440.837	2441.839	1.002	0.920	Complies
2480 MHz	2478.837	2479.836	0.999	0.919	Complies

For GFSK: Ch. Separation Limits: > 20dB bandwidth

CH00 -1Mbps

CH39 -1Mbps

CH78 -1Mbps

Temperature:	25℃	Relative Humidity:	50%
Test Mode:	CH00 / CH39 / CH78 (π/4-DQPSK(2Mbps) Mode)	Test Voltage:	DC 3.7V

Frequency	Mark1 Frequency （MHz）	Mark2 Frequency （MHz）	Ch. Separation (MHz)	Limit (MHz)	Result
2402 MHz	2402.002	2403.001	0.999	0.859	Complies
2441 MHz	2441.002	2442.001	0.999	0.858	Complies
2480 MHz	2479.002	2480.001	0.999	0.857	Complies

For π/4-DQPSK(2Mbps): Ch. Separation Limits: > two-thirds 20dB bandwidth

CH00 -2Mbps

CH39 -2Mbps

CH78 -2Mbps

Temperature:	25℃	Relative Humidity:	50%
Test Mode:	CH00 / CH39 / CH78 (8DPSK(3Mbps)Mode)	Test Voltage:	DC 3.7V

Frequency	Mark1 Frequency （MHz）	Mark2 Frequency （MHz）	Ch. Separation (MHz)	Limit (MHz)	Result
2402 MHz	2402.002	2403.001	0.999	0.843	Complies
2441 MHz	2441.002	2442.001	0.999	0.843	Complies
2480 MHz	2479.011	2480.001	0.990	0.845	Complies

For 8DPSK(3Mbps):Ch. Separation Limits: > two-thirds 20dB bandwidth

CH00 -3Mbps

CH39 -3Mbps

CH78 -3Mbps

8. BANDWIDTH TEST

8.1 LIMIT

FCC Part15 15.247,Subpart C				
Section	Test Item	Limit	FrequencyRange (MHz)	Result
15.247 (a)(1)	Bandwidth	(20dB bandwidth)	2400-2483.5	PASS

Spectrum Parameter	Setting
Attenuation	Auto
Span Frequency	> Measurement Bandwidth or Channel Separation
RB	30 kHz (20dB Bandwidth) / 30 kHz (Channel Separation)
VB	100 kHz (20dB Bandwidth) / 100 kHz (Channel Separation)
Detector	Peak
Trace	Max Hold
Sweep Time	Auto

8.2 TEST PROCEDURE

a. The EUT was directly connected to the spectrum analyzer and antenna output port as show in the block diagram below,

b. Spectrum Setting: RBW= 30KHz, VBW=100KHz, Sweep time = Auto.

8.3 TEST SETUP

8.4 EUT OPERATION CONDITIONS

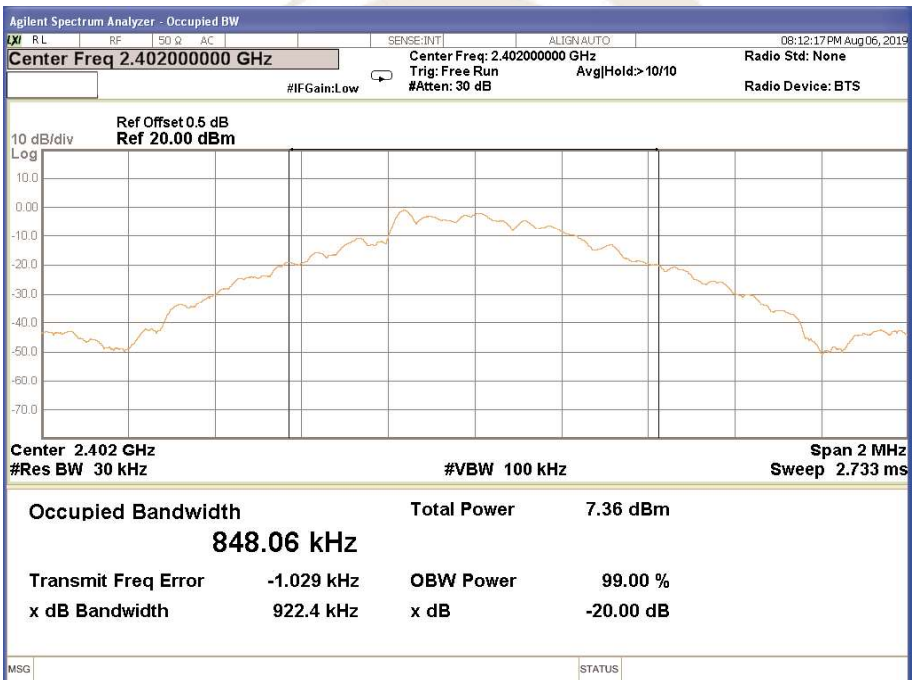
The EUT tested system was configured as the statements of 2.4 Unless otherwise a special operating condition is specified in the follows during the testing.

8.5 TEST RESULTS

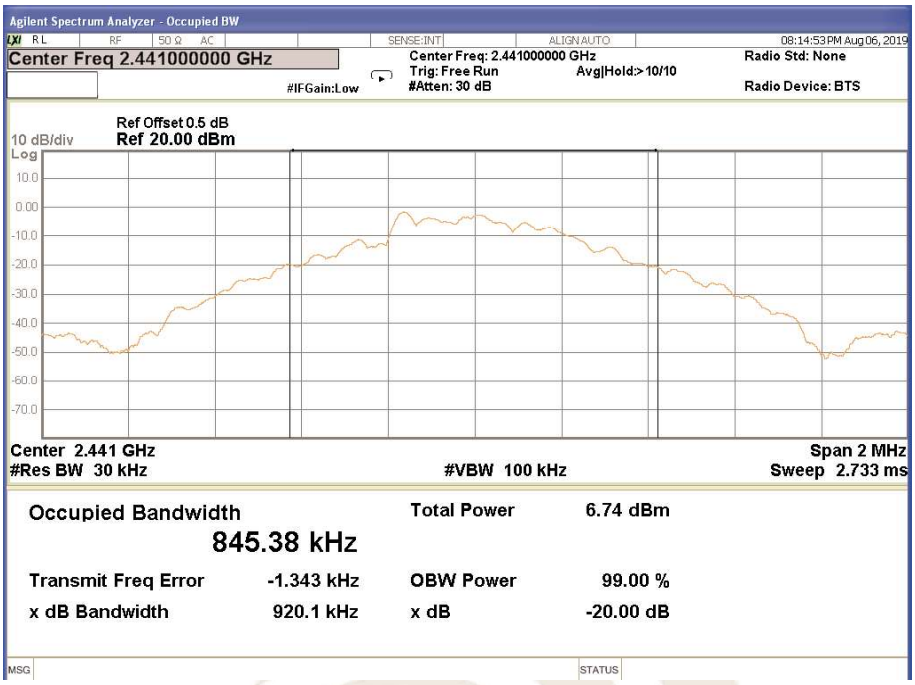
Temperature:	25℃	Relative Humidity:	50%
Test Mode:	GFSK(1Mbps) CH00 / CH39 / C78	Test Voltage:	DC 3.7V

Frequency	20dB Bandwidth (MHz)	Result
2402 MHz	0.922	PASS
2441 MHz	0.92	PASS
2480 MHz	0.919	PASS

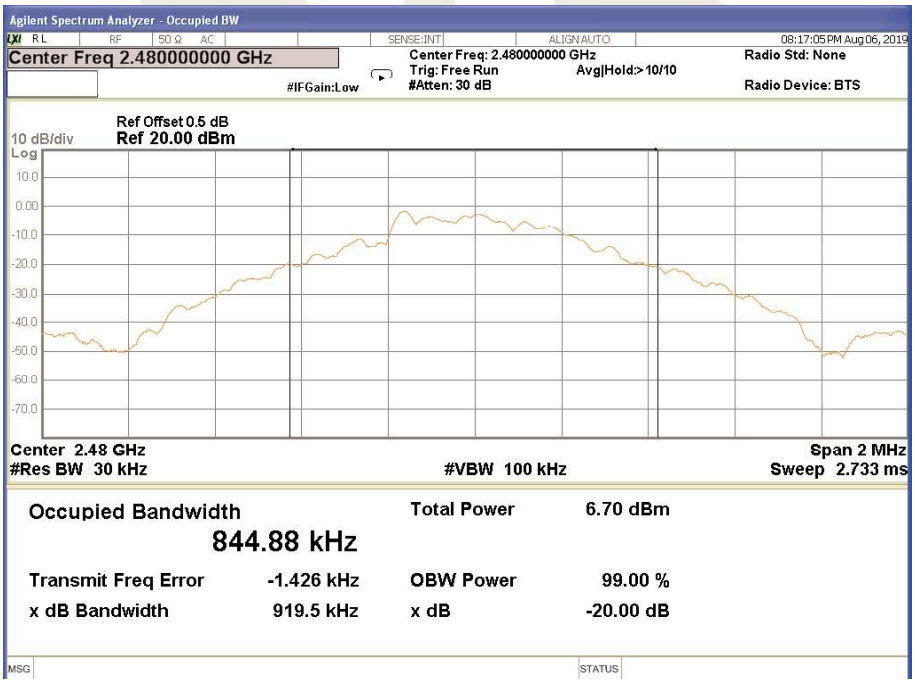
CH00 -1Mbps



CH39 -1Mbps



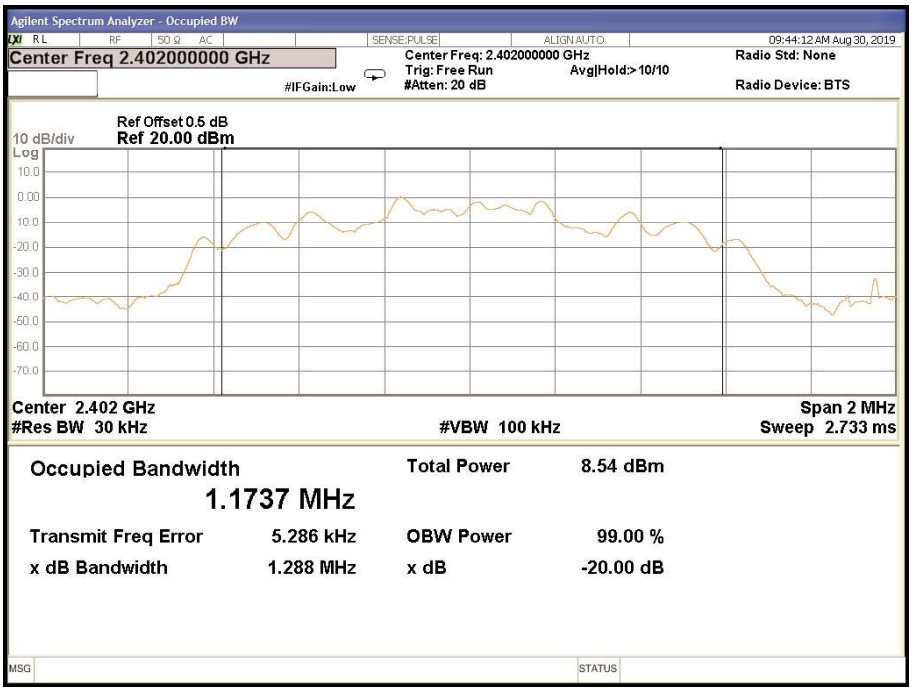
CH78 -1Mbps



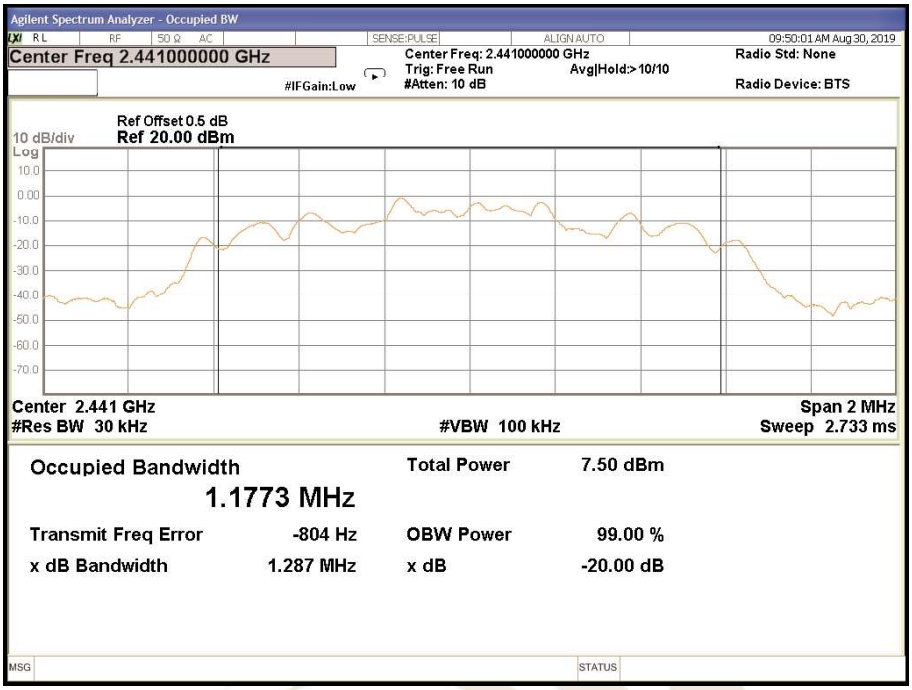
Temperature:	25℃	Relative Humidity:	50%
Test Mode:	π/4-DQPSK(2Mbps) CH00 / CH39 / C78	Test Voltage:	DC 3.7V

Frequency	20dB Bandwidth (MHz)	Result
2402 MHz	1.288	PASS
2441 MHz	1.287	PASS
2480 MHz	1.286	PASS

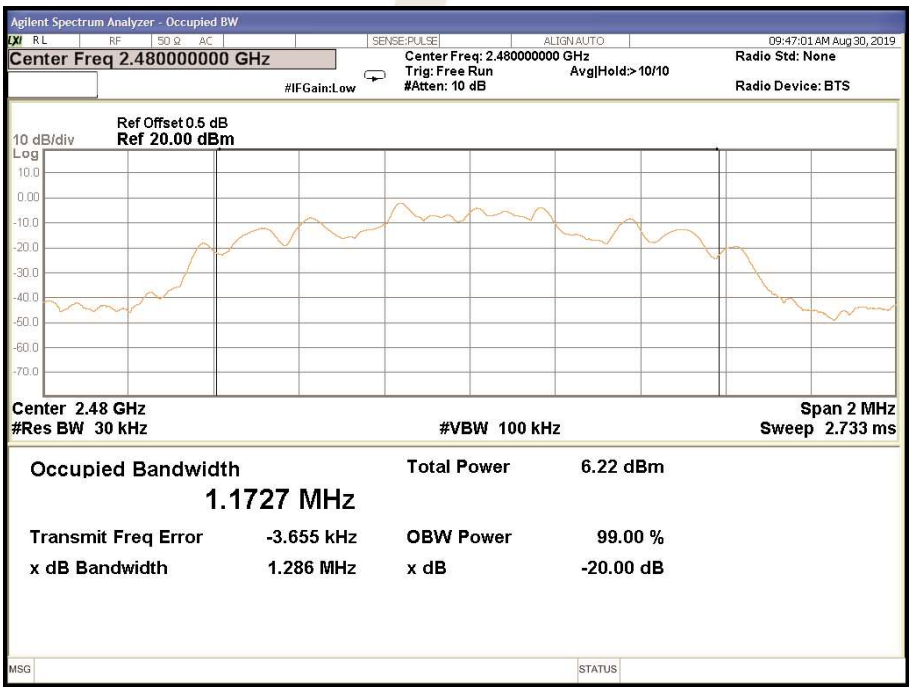
CH00 -2Mbps



CH39 -2Mbps



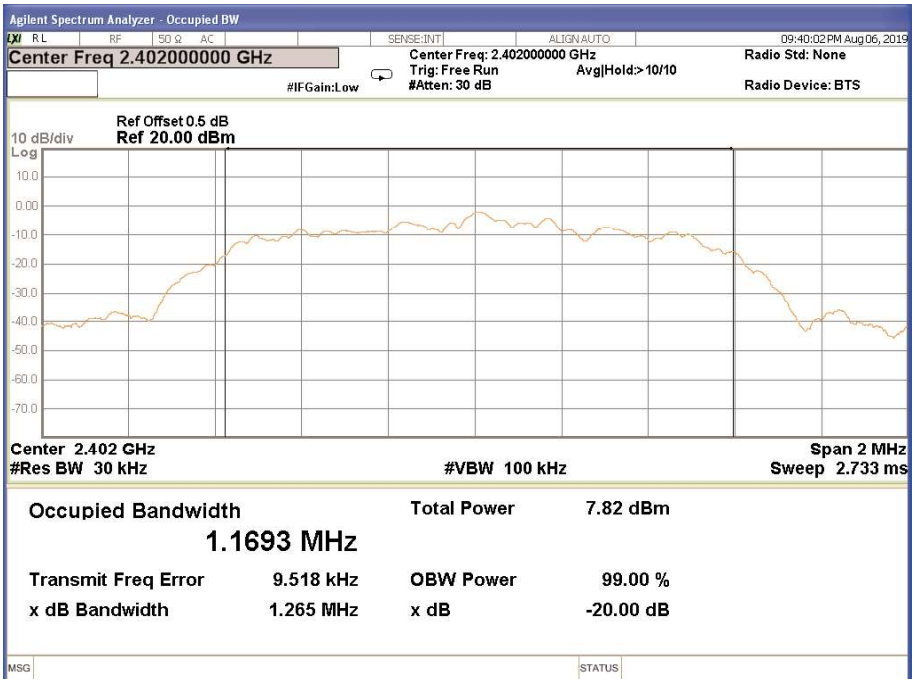
CH78 -2Mbps



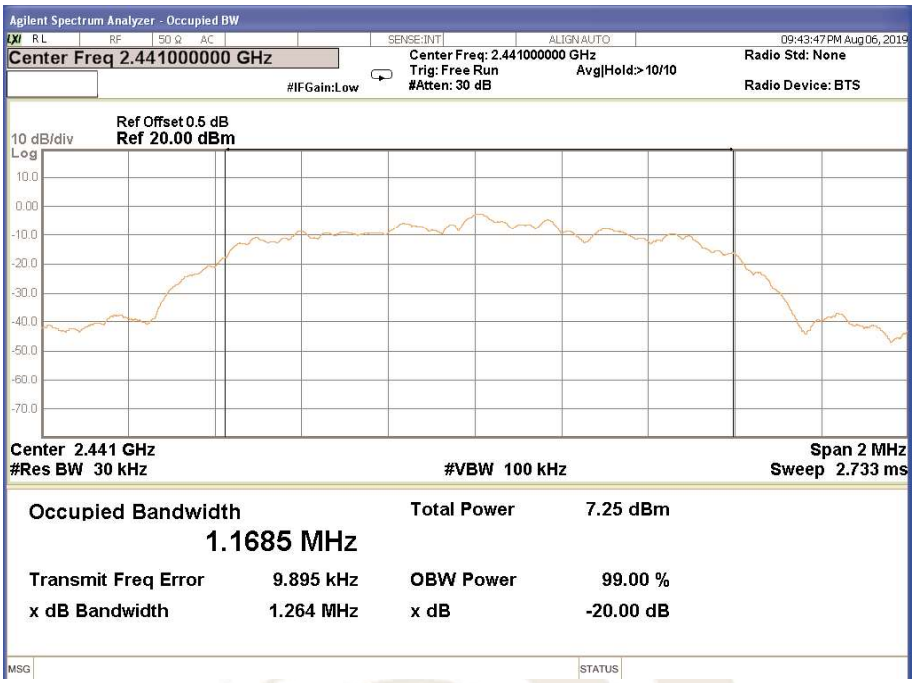
Temperature:	25℃	Relative Humidity:	50%
Test Mode:	8DPSK(3Mbps) CH00 / CH39 / CH78	Test Voltage:	DC 3.7V

Frequency	20dB Bandwidth (MHz)	Result
2402 MHz	1.265	PASS
2441 MHz	1.264	PASS
2480 MHz	1.268	PASS

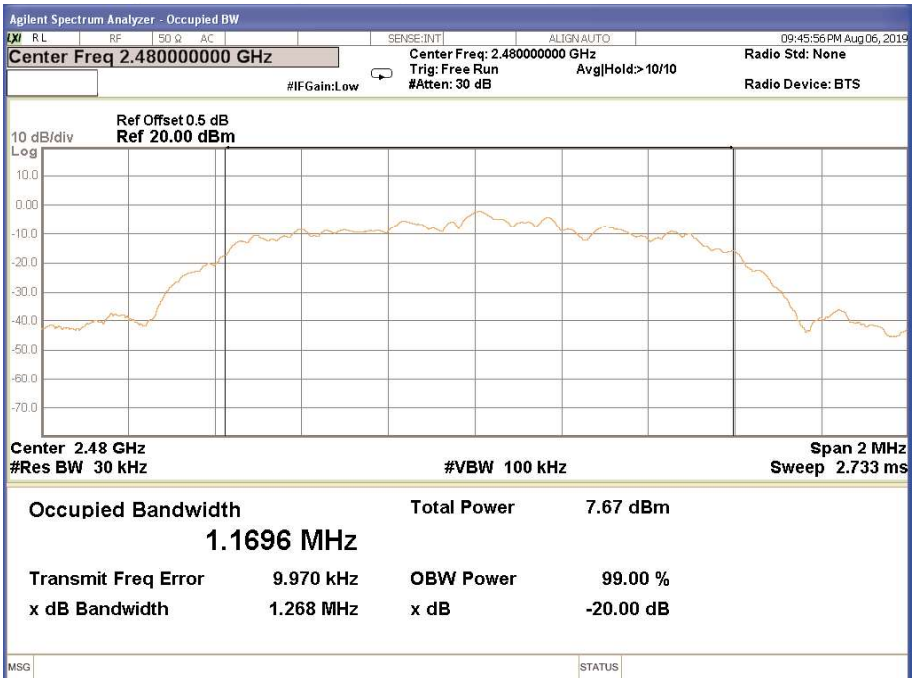
CH00 -3Mbps



CH39 -3Mbps



CH78 -3Mbps



9. OUTPUT POWER TEST

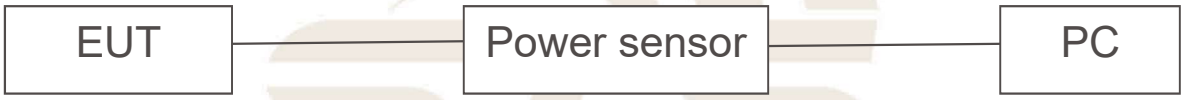
9.1 LIMIT

FCC Part 15.247,Subpart C				
Section	Test Item	Limit	FrequencyRange (MHz)	Result
15.247 (a)(1)&(b)(1)	Output Power	1 W or 0.125W	2400-2483.5	PASS
		if channel separation > 2/3 bandwidthprovided thesystems operatewith an output power no greater than125 mW(20.97dBm)		

9.2 TEST PROCEDURE

a. The EUT was directly connected to the Power Sensor&PC

9.3 TEST SETUP



9.4 EUT OPERATION CONDITIONS

The EUT tested system was configured as the statements of 2.4 Unless otherwise a special operating condition is specified in the follows during the testing.

9.5 TEST RESULTS

Temperature:	25℃	Relative Humidity:	60%
Test Voltage:	DC 3.7V		

Mode	Channel Number	Frequency (MHz)	Peak Power (dBm)	Average Power (dBm)	Limit (dBm)
GFSK(1M)	0	2402	0.78	-0.48	30.00
	39	2441	0.21	-1.05	30.00
	78	2480	0.18	-1.28	30.00

Note: the channel separation >20dB bandwidth

Mode	Channel Number	Frequency (MHz)	Peak Power (dBm)	Average Power (dBm)	Limit (dBm)
π/4-DQPSK(2M)	0	2402	2.95	-0.69	20.97
	39	2441	2.57	-1.12	20.97
	78	2480	1.92	-1.76	20.97

Note: the channel separation >2/3 20dB bandwidth

Mode	Channel Number	Frequency (MHz)	Peak Power (dBm)	Average Power (dBm)	Limit (dBm)
8-DPSK(3M)	0	2402	3.46	-0.69	20.97
	39	2441	3.12	-1.09	20.97
	78	2480	2.77	-1.33	20.97

Note: the channel separation >2/3 20dB bandwidth

10. ANTENNA REQUIREMENT

10.1 STANDARD REQUIREMENT

15.203 requirement: For intentional device, according to 15.203: an intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device.

10.2 EUT ANTENNA

The EUT antenna is ceramics Antenna. It comply with the standard requirement.

APPENDIX-PHOTOS OF TEST SETUP

Note: See test photos in setup photo document for the actual connections between Product and support equipment.

※※※※※END OF THE REPORT※※※※※